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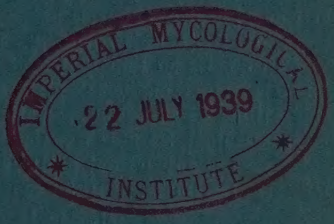

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VOLUME XXIII, № 4

TABLE DES MATIÉRES

Pages

MATHÉMATIQUES

A. Plessner. Über Funktionen eines maximalen Operators 327
V. Šmulian. Sur les topologies différentes dans l'espace de Banach . . . 331

HYDRODYNAMIQUE

Valentin V. Vedernikov. Sur la théorie du drainage 335

PHYSIQUE

A. Jdanoff, L. Myssowsky et **M. Myssowskaja.** Les traces des noyaux de recul à la désintégration de l'urane par les neutrons 338
L. A. Sliv. On the Impulse of Recoil by Beta-Decay 340
P. S. Vadilo. Methods for the Investigation of the Structure of Ice . . 343

PHYSIQUE TECHNIQUE

A. Arenberg. Sur la résistance du rayonnement du vibrateur de Hertz . 345

BIOPHYSIQUE

N. T. Fedorov. Concerning My Article «Some Regularities Underlying the Effect of Indirect Stimuli (Nebenreiz) upon the Discrimination Sensitivity of the Eye» 350

GÉOCHIMIE

S. A. Borovick and **J. D. Gotman.** Content of Rare and Other Elements in the Cassiterites of Different Genesis from USSR Deposits According to Spectrum Analysis Data 351
O. Vladimirov, S. Kraskovski and **A. Semenov.** Geothermal Measurements in Monche-Tundra 355

Pages

STRATIGRAPHIE

D. Nazarenko. Finding of the Marine Upper Devonian at the North-Western Margins of the Donetz Basin 359

BIOLOGIE

M. M. Kamshilov. Selection as a Factor Altering the Dependence of Characters on Variation in Environmental Conditions 362

GÉNÉTIQUE

M. I. Hadjinov. A Dominant Mutable Gene for Purple Colour in the *R* Series of Multiple Allelomorphs in Maize 366

AGROPHYSIOLOGIE

G. V. Zabluda. Drought Resistance of Spring Wheats in Various Periods of Formation of Vegetative and Reproductive Organs 370
T. S. Sulakadze. Amounts of Ice in Frozen Winter Plants 373

PHYSIOLOGIE VÉGÉTALE

G. V. Zabluda. On the Phases of Formation of Generative Organs in Wheat 376
P. G. Tavadzé. Niveau des yeux sur le sarment de vigne, sujet ou greffon, comme facteur déterminant la proportion de reprises 380

ANATOMIE DES PLANTES

V. G. Alexandrov and **O. G. Alexandrova.** Morphology of the Ovary and of the Immature Fruit in Wheat 384
V. G. Alexandrov and **O. G. Alexandrova.** Anatomical Characters of the Achenes of the Early Maturing and Late Maturing Wheat 388

PHYTOPATHOLOGIE

V. A. Jablokova. Response of the Mycellium of *Ustilago tritici* in Wheat Grain to Ultra-Violet Rays as Dependent upon Its Condition 392

MÉCANIQUE DU DÉVELOPPEMENT

O. I. Schmalhausen. Rôle of the Olfactory Sac in the Development of the Cartilage Capsule of the Olfactory Organ in *Urodela* 395
N. I. Dragomirov. Morphogenetic Interaction between the Eye Rudiment and the Covering Ectoderm 399

ZOOLOGIE

V. D. Bryuzgin. A Procedure for Investigating Age and Growth in *Reptilia* 403

PARASITOLOGIE

J. D. Kirschenblatt. A New Parasite of the Lungs in Rodents 406

PALÉOZOOLOGIE

B. S. Sokolov. Stratigraphical Value and Types of *Chaetetidae* of the Carboniferous of the USSR 409

Rédacteur en chef A. Fersman. Rédacteur S. Bernstein.

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MATHEMATIK

ÜBER FUNKTIONEN EINES MAXIMALEN OPERATORS

Von A. PLESSNER

(Vorgelegt von I. M. Vinogradow, Mitglied der Akademie, d. 19.III.1939)

Das A-Mass und A-Integral. Es sei $E(\Delta)$ die Spektralfunktion des maximalen hermiteschen Operators A^*. Setzt man

$$\Gamma = \sum_{k=1}^{\infty} \Delta_k,\ \Delta_i \Delta_k = 0;\ E(\Gamma) = \sum_{k=1}^{\infty} E(\Delta_k)$$

(starke Konvergenz), und für eine beliebige Menge M auf der reellen Achse $\bar{\mu}(M; h) = \inf_{\Gamma \supset M} (E(\Gamma) h, h)$, so ergibt sich die Existenz des äusseren Masses $\bar{E}(M)$, so dass $(\bar{E}(M) h, h) = \bar{\mu}(M; h)$. Das innere Mass $E(M)$ wird entsprechend durch $E(M) = E - \bar{E}(I - M)$, $I = (-\infty, \infty)$ definiert, und durch $E(M) = \bar{E}(M) = E(M)$ ein Borelsches System der A-messbaren Mengen M ausgesondert, das die Intervalle und somit sämtliche Borelsche Mengen enthält. Das A-Mass $E(M)$ ist eine absolut additive Mengenfunktion, indem im Sinne der starken Konvergenz $E(M) = E(M_1) + E(M_2) + \ldots + E(M_n) + \ldots$, wenn $M = \sum_{k=1}^{\infty} M_k$, $M_k M_e = 0$ ist. Eine reelle Funktion $F(\sigma)$ heisst A-messbar, wenn sämtliche $M(F(\sigma) > \alpha)$ A-messbar sind. Für solche Funktionen lassen sich die Lebesgue'schen Summen $\sum l_k E(M_k)$ bilden, wo $M_k = M(l_{k-1} \leqslant F(\sigma) < l_k)$ und $l_k - l_{k-1} < \delta$ ist. Für beschränkte $F(\sigma)$ konvergieren für $\delta \to 0$ diese Lebesgue'schen Summen stark und für ihren Grenzwert, das A-Integral, setzen wir:

$$\int_{-\infty}^{\infty} F(\xi)\, dE(\Delta_\xi) = \lim_{\delta \to 0} \sum_k l_k E(M_k). \qquad (1)$$

Im Falle nicht-beschränkter $F(\sigma)$ setzen wir voraus, dass $F(\sigma)$ mit Ausnahme einer A-Nullmenge definiert und endlich ist, und betrachten diejenigen Elemente f aus H, für die das Integral

$$\int_{-\infty}^{\infty} |F(\xi)|^2\, d(E(\Delta_\xi) f, f) < \infty \qquad (2)$$

* Für die eingeführten Begriffe und Bezeichnungen vgl. (1).

also endlich bleibt. Für diese f konvergieren die Lebesgue'schen Summen (1) wieder stark und wir bezeichnen ihren Grenzwert durch das gleiche Integralsymbol (1), indem wir übereinkommen, dass der Definitionsbereich des durch dieses Integralsymbol erklärten Operators aus denjenigen f besteht, die die Bedingung (2) erfüllen. Die A-Messbarkeit und das A-Integral werden leicht auf komplexwertige Funktionen ausgedehnt, indem man Realteil und Imaginärteil getrennt behandelt.

Funktionen von A im weiteren Sinne. Funktionen $F(\sigma)$ der bisher betrachteten Art nennen wir zur weiteren Klasse gehörig. Für diese setzen wir:

$$F(A) = \int_{-\infty}^{\infty} F(\xi)\, dE(\Delta_\xi)$$

und nennen den Operator $F(A)$ Funktion von A im weiteren Sinne. Diese Zuordnung $F(\sigma) \sim F(A)$ wird linear, wenn $a_1F_1(A) + a_2F_2(A)$ durch $a_1F_1(A) + a_2F_2(A) \sim a_1F_1(\sigma) + a_2F_2(\sigma)$ definiert wird. Man hat dann für Elemente f, die zum Definitionsbereich von $F_1(A)$ und $F_2(A)$ gehören: $[a_1F_1(A) + a_2F_2(A)]f = a_1F_1(A)f + a_2F_2(A)f$.

Satz I. *Wenn $G(A)F(A)f$ sinnvoll ist, so hat man:*

$$(G(A)F(A)f, f) = \int_{-\infty}^{\infty} F(\xi)\, G(\xi)\, d(E(\Delta_\xi)f, f) -$$

$$- \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} F(\xi)\, G(\eta)\, d_\xi d_\eta (D(\delta_\xi, \Delta_\eta)f, f),$$

wo $D(\delta, \Delta)$ *die Diskrepanz von A bedeutet* (1).

Allgemein kann $G(A)F(A)$ nicht wieder als Funktion von A betrachtet werden und es ist $F(A)G(A) \neq G(A)F(A)$; für den Kommutator:

$$[F(A), G(A)] = G(A)F(A) - F(A)G(A)$$

erhält man die Darstellung:

$$([F(A), G(A)]f, f) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} (G(\xi)F(\eta) - F(\xi)G(\eta))\, d_\xi d_\eta (D(\delta_\xi, \Delta_\eta)f, f).$$

Funktionen von A im engeren Sinne. Wir betrachten in der λ-Halbebene die dort regulär analytischen Funktionen $F(\lambda)$, welche die Bedingungen erfüllen ($\lambda = \sigma + i\tau$, $\tau \neq 0$):

1) $$\int_{-\infty}^{\infty} \frac{\overset{+}{\lg}|F(\lambda)|}{1+\sigma^2}\, d\sigma = O(1) \quad \tau \to 0;$$

2) das unbestimmte Integral $\int_\Delta \overset{+}{\lg}|F(\lambda)|\, d\sigma$ ist eine für $\tau \to 0$ gleichmässig totalstetige Intervallfunktion, wenn die Veränderlichkeit von Δ auf ein endliches Intervall eingeschränkt wird;

3) $$\lim_{R\to\infty} \frac{1}{R} \int_0^{\pi} \overset{+}{\lg}|F(\varepsilon\rho i + Re^{i\varphi})| \sin\varphi d\varphi = 0,$$

$$\rho > 0, \quad \varepsilon = \operatorname{sgn}(\operatorname{Im}\lambda).$$

Diese Funktionenklasse bezeichnen wir mit Ω.

Satz II. *$\mathfrak{Q}$ bildet einen Funktionenring, dessen Elemente $F(\lambda)$ die folgende Darstellung zulassen:*

$$F(\lambda) = e^{\varepsilon i t \lambda} B(\lambda) e^{(u_0+u)+i(v_0+v)}$$

wo $t \geqslant 0$, $B(\lambda) = \prod_k \frac{\lambda - a_k}{\lambda - \bar{a}_k}$ (a_k Nullstellen von $F(\lambda)$) und

$$u = \frac{\varepsilon}{\pi} \int_{-\infty}^{\infty} \frac{\tau \lg p(\xi)}{(\sigma-\xi)^2+\tau^2} d\xi;\ u_0 = -\frac{\varepsilon}{\pi} \int_{-\infty}^{\infty} \frac{\tau dq(\Delta_\xi)}{(\sigma-\xi)^2+\tau^2},$$

wo $p(\xi) \geqslant 0$, $q(\Delta)$ eine nichtnegative additive und singuläre Intervallfunktion, deren Ableitung fast überall also verschwindet und

$$\int_{-\infty}^{\infty} \frac{|\lg p(\xi)|}{1+\xi^2} d\xi < \infty;\ \int_{-\infty}^{\infty} \frac{dq(\Delta_\xi)}{1+\xi^2} < \infty$$

ist. v und v_0 sind konjugiert harmonische Funktionen zu u und u_0. $F(\lambda)$ besitzt für $\tau \to 0$ (allgemeiner bei Annäherung in Winkelräumen) fast überall endliche Grenzwerte $\lim_{\tau \to 0} F(\lambda) = F(\sigma)$. Für die Grenzfunktion $F(\sigma)$ gilt $|F(\sigma)| = p(\sigma)$.

Satz III. *$\mathfrak{Q}$ enthält alle beschränkten analytischen Funktionen in der λ-Halbebene, sowie diejenigen, für welche die Integrale beschränkt sind:*

$$\text{(a)} \quad \int_{-\infty}^{\infty} |F(\lambda)|\, d\sigma < \infty; \quad \text{(b)} \quad \int_{-\infty}^{\infty} |F(\lambda)|^2 d\sigma < \infty$$

(übrigens gilt dies, wenn statt 1, 2 ein beliebiger Exponent p gesetzt wird). In diesen drei Fällen ist die Grenzfunktion $F(\sigma)$ offenbar beschränkt im Intervall $(-\infty, \infty)$, integrierbar [entspr. (a)], oder $|F(\sigma)|^2$ ist integrierbar [entspr. (b]. Umgekehrt, wenn für ein $F(\lambda)$ aus $\mathfrak{Q}$ die Grenzfunktion $F(\sigma)$ in $(-\infty, \infty)$ 1) beschränkt, 2) integrierbar, 3) $|F(\sigma)|^2$ ist integrierbar, so gilt für $F(\lambda)$ bzw.: 1) $F(\lambda)$ ist beschränkt, 2) das Integral (a) ist beschränkt, 3) das Integral (b) ist beschränkt.

Die Funktion $F(\sigma)$ der weiteren Klasse werden wir zugleich zur engeren Klasse zählen, wenn sie fast überall mit der Grenzfunktion einer Funktion $F(\lambda)$ aus $\mathfrak{Q}$ übereinstimmt. Unter der konjugierten Klasse verstehen wir die Gesamtheit aller $\overline{F}(\sigma)$, wo $F(\sigma)$ zur engeren Klasse gehört. Die engere Klasse, sowie die konjugierte Klasse bilden einen Funktionenring. Die Operatoren $F(A)$ bzw. $\overline{F}(A)$ werden entsprechend Funktion von A im engeren Sinne und konjugierte Funktion von A genannt, wenn $F(\sigma)$ zur engeren Klasse gehört. Es ist

$$F_2(A) F_1(A) f = \int_{-\infty}^{\infty} F_1(\xi) F_2(\xi)\, dE(\Delta_\xi) f,$$

wenn $F_1(A)$ Funktion von A im engeren Sinne oder $F_2(A)$ eine konjugierte Funktion von A ist.

Satz IV. *Für Funktionen von A im engeren Sinne gilt die Multiplikativität der Zuordnung $F_1(\sigma) F_2(\sigma) \sim F_2(A) F_1(A)$ in dem Sinne, dass wenn $F(\sigma) = F_1(\sigma) F_2(\sigma)$ gezetzt wird, $F(A) f = F_2(A) F_1(A) f$ für diejenigen f ist, für welche die rechte Seite sinnvoll ist. Wir definieren: $F_2(A) F_1(A) = F(A)$. Bei dieser Definition der Multiplikation bilden die Funktionen von A im engeren Sinne einen Abelschen Operatorenring.*

Satz IV'. *Für die konjugierten Funktionen von A gelten die im Satz IV für Funktionen von A im engeren Sinne angegebenen Eigenschaften.*

Satz V. *Das Linearsystem der Operatoren, die Funktionen von A im weiteren Sinne sind, besitzt die Eigenschaft, dass die Multiplikation eines Elementes dieser Gesamtheit rechts mit einer Funktion von A im engeren Sinne bzw. links mit einer konjugierten Funktion von A wieder ein Element des Linearsystems ergibt; ist ausserdem $G(\sigma)=F_2(\sigma)F(\sigma)F_1(\sigma)$, wo $F_1(\sigma)$ zur engeren Klasse gehört, $F_2(\sigma)$ zur konjugierten, so gilt $G(A)f=F_2(A)F(A)F_1(A)f$ für diejenigen f, für welche die rechte Seite sinnvoll ist. Es ist auch hier zweckmässig $F_2(A)F(A)F_1(A)=G(A)$ zu definieren.*

Der Kommutator $[F(A), G(A)]$ berechnet sich:

$$([F(A),\ G(A)]f, f)=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} G(\xi)F(\eta)\,d_\xi d_\eta\,(D(\delta_\xi, \Delta_\eta)f, f),$$

wenn $F(A)$ eine Funktion von A im engeren Sinne oder $G(A)$ eine konjugierte Funktion von A ist.

Satz VI. *Wenn $F(\sigma)$ zur engeren bzw. zur konjugierten Klasse gehört und nur auf einer A-Nullmenge verschwindet (diese letzte Bedingung wird überflüssig, wenn in der kanonischen Zerlegung von A der hypermaximale Teil A_0 [1] nicht auftritt), so besitzt der Operator $F(A)$ einen linken bzw. rechten reziproken Operator $F^{-1}(A)$* $\left(F^{-1}(\sigma)=\frac{1}{F(\sigma)}\right)$.

Der Satz VI findet seine Anwendung bei Lösung der Funktionalgleichung $F(A)f=g$, wo $F(A)$ eine Funktion im engeren Sinne oder konjugierte Funktion ist.

Auf Grund der mitgeteilten Resultate kann man der Heaviside'schen Operationskalkül in die allgemeine Spektraltheorie einordnen, und weite Grenzen seiner Anwendbarkeit angeben.

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MATHÉMATIQUES

SUR LES TOPOLOGIES DIFFÉRENTES DANS L'ESPACE DE BANACH

Par V. ŠMULIAN

(Présenté par M. A. Kolmogoroff, de l'Académie, le 11. III. 1939)

I. Soit $\mathfrak{e}$ un espace linéaire topologique (1). Un ensemble $S \subset \mathfrak{e}$ sera nommé compact au sens de Moor (2), si pour chaque suite dirigée (3) $\{x_\alpha\} \subset S$ il existe un élément $y \in \mathfrak{e}$ tel que pour chacun de ses voisinages U et pour chaque indice α il existe un indice $\beta > \alpha$ tel que $x_\beta \in U$.

Il est alors facile à démontrer le théorème suivant.

Théorème 1. *Un ensemble fermé $S \subset \mathfrak{e}$ est bicompact dans le cas et dans ce cas seulement où il est compact au sens de Moor.*

Désignons par $a_1S_1 + \ldots + a_nS_n$ l'ensemble des éléments de la forme $a_1x_1 + \ldots + a_nx_n$, où $x_1 \in S_1, \ldots, x_n \in S_n$ ($a_1, \ldots, a_n$ étant des nombres fixes arbitraires et $S_1, \ldots, S_n$ des ensembles fixes arbitraires).

Théorème 2 (4). *Si les ensembles $S_1, \ldots, S_n$ sont bicompacts et $a_1, \ldots, a_n$ sont les nombres arbitraires fixes, on a:*

1) *l'ensemble $S = a_1S_1 + \ldots + a_nS_n$ est bicompact et*

2) *l'ensemble des éléments de la forme $t_1x_1 + \ldots + t_nx_n$, où $x_1 \in S_1, \ldots, x_n \in S_n$, $t_1 \geqslant 0, \ldots, t_n \geqslant 1$, $\sum_1^n t_i = 1$ est bicompact.*

Corollaire. *Si $S_1, \ldots, S_n$ sont des ensembles bicompacts convexes le plus petit ensemble convexe qui les contient est encore bicompact.*

II. Soit E ici et dans la suite un ensemble du type (B). L'espace conjugué sera désigné par $\overline{E}$.

Pour chaque nombre cardinal ϑ et pour chaque ensemble $\mathfrak{M}$ de puissance $\leqslant \vartheta$ appartenant à la sphère unitaire de l'espace $\overline{E}(E)$ désignons par $U_{x;\,\vartheta}(\mathfrak{M};\,\varepsilon)\,(U_{f;\,\vartheta}(\mathfrak{M};\,\varepsilon))$ l'ensemble de tous les points $x(f)$ de l'espace $E(\overline{E})$, pour lesquels on a pour tous les $f \in \mathfrak{M}$ $(x \in \mathfrak{M})$ l'inégalité

$$|f(x)| < \varepsilon.$$

Le système de tous les ensembles $U_{x;\,\vartheta}(\mathfrak{M};\,\varepsilon)\,(U_{f;\,\vartheta}(\mathfrak{M};\,\varepsilon))$, où ϑ est un nombre cardinal fini arbitraire, sera considéré comme ensemble de tous les voisinages du point Θ. Alors l'ensemble $E(\overline{E})$ devient un espace topologique linéaire que nous désignerons par

$$E_T\,((\overline{E_T})).$$

Comme la régularité de l'espace E signifie que l'ensemble des éléments $x \in E$ tel que $\|x\| \leqslant 1$ est bicompact dans l'espace E_T (5), on déduit du théorème 1 le

Théorème 3. *L'ensemble E est régulier dans le cas et dans ce cas seulement où sa sphère $\|x\| \leqslant 1$ est compacte au sens de Moor dans E_T.*

La suffisance de cette condition a été démontrée récemment par Taylor (6).

L. Alaoglu a démontré récemment (7) que tout ensemble $S \subset \overline{E}$ borné en norme est bicompact dans $(\overline{E_T})$ s'il est fermé dans cette topologie. Ainsi, grâce à la proposition d'Alaoglu, il suit évidemment du théorème 1

Théorème 4. *La sphère unitaire de l'espace $\overline{E}$ est compacte au sens de Moor dans $(\overline{E_T})$.*

L'ensemble $K \subset \overline{E}$ est nommé régulièrement fermé, si pour chaque élément $f_0 \overline{\in} K$ il existe un élément $x_0 \in E$ tel que

$$\sup_{f \in K} f(x_0) < f_0(x_0).$$

Nous aurons besoin pour la suite du théorème suivant non publié encore de M. Krein et de l'auteur. Si l'ensemble $S \subset \overline{E}$ est borné en norme, le plus petit ensemble fermé convexe contenant S coïncide avec l'ensemble de tous les éléments de $\overline{E}$ de la forme

$$\int_S f(x)\, d\Phi(e),$$

où $\Phi(e)$ est une fonction non-négative additive d'ensemble $e \subset S$ et $\underset{S}{\text{var}}\,[\Phi(e)] = 1$.

En vertu de la proposition d'Alaoglu, on en déduit facilement la proposition suivante de F. Gantmacher. La classe des ensembles $S \subset \overline{E}$ convexes bornés et régulièrement fermés coïncide aves la classe des ensembles convexes bicompacts dans $(\overline{E_T})$.

Ainsi, grâce au théorème 2, nous arrivons au théorème suivant de M. Krein et de l'auteur (qui, lui aussi, n'a pas encore été publié).

Théorème 5. *Soient $S_1, \ldots, S_n$ des ensembles arbitraires bornés convexes et régulièrement fermés dans $\overline{E}$ et soient $a_1, \ldots, a_n$ n nombres arbitraires. On a alors*:

1) *l'ensemble $S = a_1 S_1 + \ldots + a_n S_n$ est convexe et régulièrement fermé et*

2) *le plus petit ensemble convexe contenant tous les S_i est aussi régulièrement fermé.*

Si $\underline{\lim} f_n(x) \leqslant f_0(x) \leqslant \overline{\lim} f_n(x)$ pour tous les $x \in E$, on dit que f_0 est une limite dénombrable pour $\{f_n\}$.

Un ensemble borné convexe K sera nommé dénombrablement fermé, s'il existe pour chaque suite dénombrable $\{f_n\} \subset K$ un $f_0 \subset K$ qui est une limite dénombrable pour $\{f_n\}$.

Théorème 6 (8). *Si un ensemble borné et convexe $K \subset \overline{E}$ est dénombrablement fermé, le fait suivant a lieu. Si $\{x_n\}$ est une suite dénombrable d'éléments de l'espace E et si l'élément f_0 appartient au plus petit ensemble régulièrement fermé contenant K, on peut trouver un élément $f_1 \in K$ tel que*

$$f_0(x_n) = f_1(x_n) \qquad (n = 1, 2, \ldots).$$

Si cette condition est remplie, alors, quelles que soient les suites dénombrables $\{f_n\} \in K$ *et* $\{x_n\} \in E$, *on peut trouver un élément* $f_0 \in K$ *tel que*

$$\underline{\lim_{n\to\infty}} f_n(x_p) \leqslant f_0(x_p) \leqslant \overline{\lim_{n\to\infty}} f_n(x_p) \qquad (p = 1, 2, \ldots).$$

Théorème 7. *Si un ensemble borné et convexe de l'espace* $\overline{E}$ *est un sous-ensemble compact en lui-même d'un espace linéaire topologique* $(\overline{E}_T)$, *il est dénombrablement fermé. Inversement, si* K *contient toutes les limites dénombrables de toutes les suites dénombrables* $\{f_n\} \in K$, *l'ensemble* K *est un sous-ensemble compact en lui-même d'un espace linéaire topologique* $(\overline{E}_T)$.

Soit maintenant K un ensemble borné convexe et fermé dans $\overline{E}$ et soit $f_0 \in K$. Menons par le point f_0 des rayons dans toutes les directions. Marquons sur chacun de ces rayons le dernier point appartenant à K. L'ensemble de tous les points ainsi marqués (excepté le point f_0 lui-même s'il a été marqué) sera nommé la quasi-frontière de l'ensemble K (par rapport au point f_0). Désignons par $K(\Gamma)$ un ensemble convexe arbitraire situé sur la quasi-frontière K (par rapport à f_0). Joignons maintenant par des droites les points de l'ensemble $K(\Gamma)$ et le point f_0. Soit $K(\Gamma; f_0)$ l'ensemble ainsi obtenu; nous l'appellerons secteur de l'ensemble K par rapport à f_0.

Le plus petit ensemble régulièrement fermé contenant l'ensemble donné S sera nommé l'enveloppe régulière de S.

Théorème 8. *Soit* K *un ensemble convexe borné et dénombrablement fermé de* $\overline{E}$ *et soit* $f_0 \in K$. *Alors:*

1) *Chaque élément* f *appartenant à la quasi-frontière (par rapport à* f_0*) de l'enveloppe régulière de l'ensemble* K *est contenu dans l'enveloppe régulière d'un certain ensemble convexe* $K(\Gamma)$, *situé sur la quasi-frontière* K *(par rapport à* f_0*).*

2) *L'enveloppe régulière de l'ensemble* K *est formée de la réunion des enveloppes régulières de tous les secteurs de l'ensemble* K *par rapport à* f_0.

3) *L'ensemble* K *est régulièrement fermé dans le cas et dans ce cas seulement, où il contient les enveloppes régulières de tous ses secteurs par rapport à* f_0.

En tenant compte d'un théorème de E. Helly [9], nous obtenons facilement le

Théorème 9. *La sphère unitaire de l'espace* E, *considérée comme partie de l'espace* $\overline{\overline{E}}$, *forme un ensemble dense dans la topologie* $((\overline{E})_T)$ *dans toute la sphère unitaire de l'espace* $\overline{\overline{E}}$. *Donc, le plus petit ensemble fermé régulier dans* $(\overline{E})$ *contenant la sphère* $\|x\| \leqslant 1$ *coïncide avec toute la sphère unitaire de l'espace* $\overline{\overline{E}}$ **.*

III. Soit maintenant ϑ un nombre cardinal fixe infini et d'ailleurs arbitraire. Le système de tous les ensembles $U_{x;\,\vartheta}(\mathfrak{M};\,\varepsilon)$ $(U_{f;\,\vartheta}(\mathfrak{M};\,\varepsilon))$ sera considéré comme l'ensemble des voisinages du point Θ. Alors l'ensemble $E(\overline{E})$ devient un espace topologique linéaire que nous désignerons par $E_T(\vartheta)$ $((\overline{E_T})$ $(\vartheta))$ **.

Théorème 10. *Si une suite dirigée* $\{f_\alpha\} \subset \overline{E}$ *tend vers un élément* $f_0 \in \overline{E}$ *dans la topologie* $(\overline{E_T})$ (ϑ), *et si d'ailleurs l'ensemble des indices* α *a une puissance au moins égale à* ϑ, *alors* $\lim_{\alpha} \|f_\alpha - f_0\| = 0$.

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* Cette proposition dans une forme un peu différente a été obtenue récemment par H. Goldstine [19].

** L'idée de considérer une telle topologie appartient à M. A. Plessner.

Théorème 10'. *Si une suite dirigée* $\{x_\alpha\} \subset E$ *tend vers un élément* $x_0 \in E$ *dans la topologie* $E_T(\vartheta)$, *et si d'ailleurs l'ensemble des indices* α *a une puissance au moins égale à* ϑ, *alors* $\lim_\alpha \|x_\alpha - x_0\| = 0$.

Si la sphère unitaire de l'espace E est faiblement compacte, nous pouvons compléter le théorème 9 de la manière suivante.

Théorème 11. *Si la sphère* $\|x\| \leqslant 1$ *est faiblement compacte dans* E, *elle est, comme partie de l'espace* $\overline{\overline{E}}$, *un ensemble dense dans la topologie* $(\overline{(E)}_T)$ (ϑ_0)* *dans toute la sphère unitaire de l'espace* $\overline{\overline{E}}$. *On en conclut aisément que chaque élément* $F \in \overline{\overline{E}}$ *tel que* $\|F\| = 1$ *est dans ce cas de la forme*

$$F(f) = \lim_\alpha f(x_\alpha), \quad (f \in \overline{E}),$$

où tous les $\{x_\alpha\}$ *appartiennent à un certain ensemble convexe situé sur la surface de la sphère* $\|x\| = 1$ [11].

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* ϑ_0 désigne la puissance d'une suite dénombrable.

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HYDRODYNAMIQUE

SUR LA THÉORIE DU DRAINAGE

Par VALENTIN V. VEDERNIKOV

(Présenté par S. A. Tchaplyguine, de l'Académie, le 2.III.1939)

La solution des problèmes du mouvement des eaux souterraines, dont la surface libre n'est pas la ligne du courant, présente un grand intérêt. Ceci a lieu quand le débit q (rapporté à une unité de surface de la projection horizontale de la surface libre) s'infiltre du haut sur la surface libre, ou bien qu'il s'en évapore, etc. Dans ce cas sur la surface libre a lieu (fig. *A*) la condition:

$$\left.\begin{aligned} &\operatorname{tg}(\gamma-\beta)\operatorname{tg}\beta=\frac{q}{k}=q_s \\ \text{ou bien}\quad &u^2+\left(v-\frac{k+q}{2}\right)^2=\left(\frac{k-q}{2}\right)^2 \end{aligned}\right\} \qquad (1)$$

où u et v désignent les componentes de la vitesse de filtration, k — le coefficient de perméabilité et q — la quantité positive ou négative et, en général, variable le long de la surface libre. Cette condition étant satisfaite, ni $Y=\frac{\varphi}{k}$, ni $X=-\frac{\psi}{k}$ ne sont constants ni sur la surface libre, ni sur la surface de déversement. Toutefois, si les autres parties du contour de limite sont, soit la surface de déversement ($\Theta_2=y-Y=\text{const}$), rectilignes, soit des lignes verticales du courant ($\Theta_1=x-X=\text{const}$), soit des lignes horizontales équipotentiales, la solution du problème (q_s étant constant) peut être obtenue à l'aide de la méthode que nous avons donnée [1].

Posons le problème suivant (fig. *B*): on a une série infinie de drains du «diamètre» d à la profondeur h de la surface libre au centre du champ entre les drains. La distance entre les axes des deux drains est l. Dans le cas général et en tenant compte de l'influence de la capillarité du sol, sur la surface libre la hauteur piézométrique $\frac{p'}{\gamma}<0$ ou bien $\frac{p'}{\gamma}=-h_v$ [2].

Dans le point supérieur du drain la pression des eaux est $p'_d\geq 0$. On voit la correspondance des points sur les fig. *B*, *C*, *D*, *E* et *F*. Selon la formule de Christoffel-Schwarz nous obtenons:

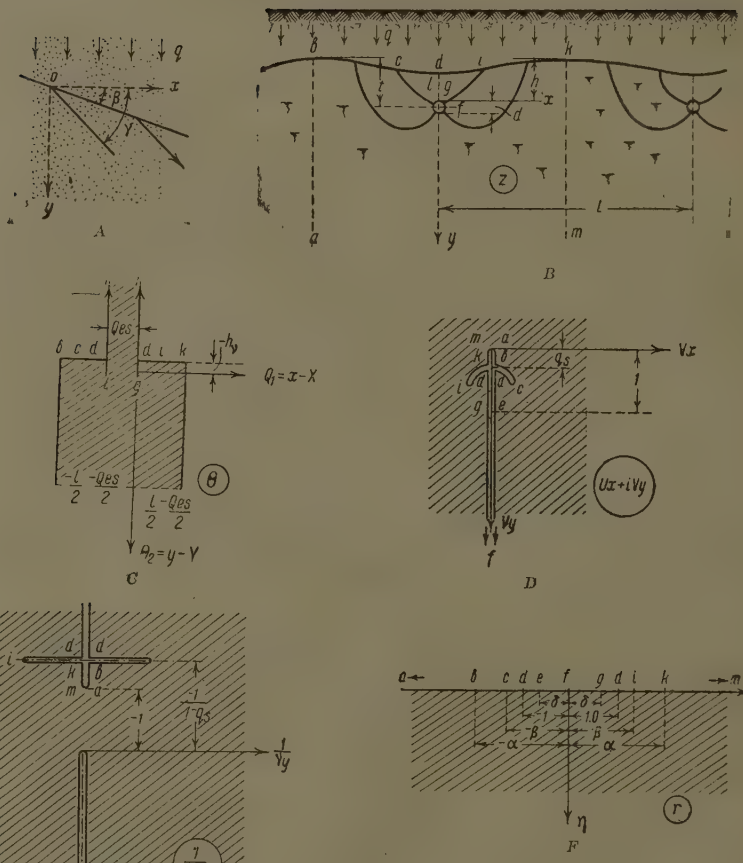
$$\begin{aligned} \frac{1}{\gamma_s}=\frac{k}{u-i(v-k)}&=A\int_0^{\zeta}\frac{(\beta^2-\zeta^2)\,\zeta d\zeta}{\sqrt{\alpha^2-\zeta^2}\sqrt{\zeta^2-1}(\zeta^2-\delta^2)^2}= \\ &=-\frac{q_s}{1-q_s}\,\frac{\sqrt{\alpha^2-\zeta^2}\sqrt{\zeta^2-1}}{\zeta^2-\delta^2}-\frac{i}{1-q_s}, \end{aligned} \qquad (2)$$

car on a

$$\zeta^2 - \delta^2 = \frac{2(\alpha^2 - \delta^2)(1 - \delta^2)}{\alpha^2 - 2\delta^2 + 1}, \tag{3}$$

où

$$\alpha = \frac{1}{q_s}\delta^2.$$



Désignons $lq_s = Q_s$ et $h - \frac{p'a}{\gamma} - h_v = H$. Puis nous trouvons par la formule de Christoffel-Schwarz

$$\Theta = D\int_0^{\zeta} \frac{(\zeta^2 - \delta^2)\,d\zeta}{\zeta\sqrt{\alpha^2 - \zeta^2}\sqrt{\zeta^2 - 1}} + C = \frac{l}{\pi}\arcsin\sqrt{\frac{\zeta^2 - 1}{\alpha^2 - 1}} -$$

$$- \frac{Q_s}{2\pi}\arcsin\frac{\zeta^2 + \alpha^2\zeta^2 - 2\alpha^2}{(\alpha^2 - 1)\zeta^2} - ih_r - \frac{Q_s}{4}. \tag{4}$$

Ensuite, selon la formule (4)(1) nous avons:

$$z = i\int \frac{1}{\gamma_s}\,d\Theta = -\frac{iQ_s}{(1 - q_s)\pi}\ln\zeta + \frac{1}{1 - q_s}\Theta - ih_1 + \frac{ih_v}{1 - q_s} \tag{5}$$

et

$$Z = i\frac{\varphi + i\psi}{k} = z - \Theta.$$

La distance entre les drains et la hauteur h_1 de la surface libre au-dessus du drain sont données par les équations:

$$l = \frac{(H - hq_s)}{(\ln\alpha - \ln\xi_0)} \cdot \frac{\pi}{q_s}, \tag{6}$$

$$h_1 = \frac{\left(\frac{p'_d}{\gamma} + h_v\right)\ln\alpha - h(1-q_s)\ln\xi_0}{(1-q_s)(\ln\alpha - \ln\xi_0)}; \tag{7}$$

α, ξ_0 et η_0 contenus dans ces équations s'obtiennent par les relations suivantes:

$$d = \frac{(H - hq_s)}{\frac{\ln\alpha}{\xi_0}} \cdot \frac{\ln\frac{\xi_0}{\eta_0}}{q_s} \tag{8}$$

$$\frac{p'_d}{\gamma} + h_v = \frac{H - hq_s}{(\ln\alpha - \ln\xi_0)\,q_s}\left[\operatorname{Arsh}\frac{\sqrt{1-\xi_0^2}}{\sqrt{\alpha^2-1}} - \right.$$
$$\left. - \frac{H - hq_s}{2(\ln\alpha - \ln\xi_0)}\operatorname{Arch}\frac{2\alpha^2 - \xi_0^2 - \alpha^2\xi_0^2}{(\alpha^2-1)\,\xi_0^2}\right], \tag{9}$$

$$\frac{p'_d}{\gamma} + h_v + d = \frac{H - hq_s}{(\ln\alpha - \ln\xi_0)\,q_s}\left[\operatorname{Arsh}\sqrt{\frac{1+\eta_0^2}{\alpha^2-1}} + \right.$$
$$\left. + \frac{H - hq_s}{2(\ln\alpha - \ln\xi_0)}\operatorname{Arch}\frac{2\alpha^2 + \eta_0^2 + \alpha^2\eta_0^2}{(\alpha^2-1)\,\eta_0^2}\right]. \tag{10}$$

Si q_s, p, h_v, d et h (ou l) sont donnés, nous pouvons trouver α, ξ_0 et η_0 à l'aide des équations (8), (9) et (10), et puis l (ou h) et h, à l'aide des équations (6) et (7).

Si p_d et h_v sont nuls, et si la dimension du drain est critique, h_1 est nul, $\delta = 1$ et $\alpha = \frac{1}{q_s}$.

Pour simplifier les calculs nous avons composé la table qui suit:

$q_s = 0$	0.05	0.10	0.20	0.35	0.435	0.50
$\frac{d}{l} = 0$	0.0092	0.0197	0.0458	0.104	0.159	0.236
$\frac{h}{l} = 0$	0.0501	0.0815	0.128	0.18	0.204	0.22

La solution du problème analogue, relatif au cas de la proximité de la couche imperméable de la surface du sol, présente une grande importance pratique.

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PHYSIQUE

LES TRACES DES NOYAUX DE RECUL À LA DÉSINTÉGRATION DE L'URANE PAR LES NEUTRONS

Par A. JDANOFF, L. MYSSOWSKY et M. MYSSOWSKAJA

(Présenté par V. G. Khlopine, de l'Académie, le 27.III.1939)

Les premières expériences concernant l'étude des noyaux de recul à la désintégration des atomes de l'urane sur des plaques photographiques à couche épaisse d'émulsion furent exécutées à l'aide d'une source de neutrons RaTh+ +Be équivalente à 280 Mc (1). Comme la source de neutrons employée donnait un fond considérable causé par les rayons γ, qui sur la plaque se révélait par une grande quantité de points noirs, nous avons répété ces expériences, employant les neutrons produits par un cyclotron au moyen de la réaction $d—d—n$. De cette manière le fond fut presque complètement éliminé. Ces expériences furent réalisées d'une façon analogique aux expériences précédentes. Une plaque photographique était placée au-dessus d'une couche épaisse de poudre d'urane métallique, à une distance d'à peu près 2—3 mm, la couche d'émulsion tournée vers l'urane. L'activation durait 10 minutes.

Par suite de l'expérience sur la plaque furent obtenues des traces de particules α de l'urane et encore d'autres traces, presque identiques aux premières, mais plus épaisses et plus contenues que nous croyons appartenir aux noyaux de recul. On peut juger de la nature de ces traces d'après la figure qui représente une photographie de deux traces, dans une émulsion spécialement préparée pour ces expériences. L'une de ces traces, continue et épaisse, 1.6 cm de longueur (dans l'air), appartient à un noyau de recul. L'autre trace, 2.5 cm de longueur, appartient à une particule α. Dans la deuxième trace des grains séparés peuvent être distingués et l'on voit de plus qu'elle est beaucoup plus fine. Néanmoins, bien que la composition de l'émulsion fût spécialement choisie pour faciliter la séparation des traces des noyaux de recul de celles des particules α, dans plusieurs cas cette séparation était très difficile à effectuer.

La cause principale en est dans le fait que beaucoup de traces sont dirigées presque normalement au plan de la plaque, donc, elles ne se soumettent pas à l'examen détaillé sous microscope. En outre la plupart des traces partent des couches intérieures de l'urane et à cause de cela ont un petit parcours. Si l'on ne compte que les traces de 1.5 cm et plus dans l'air, il paraît qu'une plaque de 6 cm^2 reçoit près de 600 noyaux de recul en une minute.

Prenant en considération que dans nos expériences la source des neutrons était à peu près 30 fois plus forte que dans ceux de Frisch (2), on peut voir que nos résultats coïncident assez bien avec les siens (15 particules par minute de 300 Mc). Cependants nos résultats se distinguent beaucoup de ceux de Roberts, Meyer et Hafstad (3) (30 particules par minute d'une source équivalente à 10 curie). Il est possible que cette contradiction puisse être expliquée par ce que Meyer et Hafstad ne comptaient que les impulsions aux énergies de 75 à 150 MeV, tandis que d'après nos expériences l'action des noyaux de recul sur la plaque photographique ne se distingue pas beaucoup de l'action des particules α. Cette circonstance peut servir à confirmer la supposition de Joliot (4) que l'énergie des noyaux de recul est de 35 MeV, et non pas de 75—150 MeV, comme le croient Roberts, Meyer et Hafstad.

Il est à noter qu'après l'activation de Bi, Au et Pt par la même source pendant trois heures on n'a pas pu remarquer de traces de noyaux de recul.

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PHYSICS

ON THE IMPULSE OF RECOIL BY BETA-DECAY

By L. A. SLIV

(Communicated by V. A. Fock, Member of the Academy, 8. III. 1939)

Bloch and Möller (1) have pointed out that the relative probability for an electron and a neutrino to be ejected at an angle Θ between the directions of their respective impulses will differ, according to whether we assume the law of interaction between the heavy nuclear particles and the electron—neutrino field in the form suggested by Fermi (2), or in that proposed by Konopinski and Uhlenbeck (3).

Yet, the requirement of the relativistic invariance of the matrix element involved in the probability of beta-decay

$$H_\beta = \pm g \int v_m^*(r)\, u_n(r)\, \psi^*(r)\, \varphi(r)\, dr$$

(where u_n and v_m are the wave functions of a heavy particle prior to and after decay, ψ — the wave function of an electron, φ — the wave function of a neutrino, g — a constant), permits of constructing five forms of the law of interaction of the Fermi type (i. e. made up of the products of the wave functions of an electron and a neutrino), namely: the vector, the tensor, the pseudo-vector, scalar and pseudo-scalar (4). The velocity of heavy particles v being small, terms of the order $\frac{v}{c}$ may be neglected. Then the pseudo-scalar variant will be altogether excluded $\left(\text{being entirely of the order } \frac{v}{c}\right)$, while the four other variants of the law of interaction of the Fermi type may be written in the form

$$\left.\begin{aligned} V_a &= g\psi^*\varphi, \qquad V_c = g\sigma_{\text{heavy}}\psi^*\sigma\varphi \\ V_b &= g\sigma_{\text{heavy}}\psi^*\beta\sigma\varphi, \quad V_d = g\psi^*\beta\varphi \end{aligned}\right\} \tag{1}$$

where σ and β are the usual Dirac matrices, σ_{heavy}—Pauli matrices.

In the case of interaction of the Konopinski-Uhlenbeck type, three forms of the law of interaction are possible

$$\left.\begin{aligned} V'_a &= g'\psi^*\beta\frac{\partial\varphi}{\partial t}, \quad V'_b = g'\sigma_{\text{heavy}}\psi^*\alpha \times \text{grad}\ \varphi, \\ V'_c &= g'\sigma_{\text{heavy}}\psi^*\beta\left\{\alpha \times \text{grad}\ \varphi - i\sigma\frac{\partial\varphi}{c\partial t}\right\} \end{aligned}\right\} \tag{2}$$

(here too allowance is made for the small velocity v of the heavy particles).

Now if we determine the relative probability for a pair of light particles to be ejected at an angle Θ to each other, we obtain for the interaction of the Fermi type

$$\left(1+\varepsilon\frac{cP_e}{E_e}\cos\Theta\right), \tag{3}$$

where P_e and E_e are the impulse and the energy of an electron, ε assumes the values $+1$, $+\frac{1}{3}$, $-\frac{1}{3}$, -1, according to whether we take as interaction law the form V_a, V_b, V_c or V_d [formula (1)]. The neutrino mass is put equal to zero. For the interaction of the Konopinski-Uhlenbeck type, the relative probability will be the same for all possible forms, having the shape

$$\left(1-\frac{cP_e}{E_e}\cos\Theta\right). \tag{4}$$

Formula (4) coincides with formula (3) for $\varepsilon=-1$.

From the probability of the emission of an electron with an impulse P_e at an angle Θ to the direction of the ejection of a neutrino, one may deduce the impulse distribution of the recoil atoms.

In the case of the Fermi type interaction, the probability for an atom to have, as a result of beta-decay, an impulse within the range $p_s-p_s+dp_s$ will be:

$$P(p_s)\,dp_s\sim p_s^2dp_s\{6E_0^2(1-\xi^2)-(3E_0^2+p_s^2)(1-\xi^3)-3(1-\xi)+ \\ +\varepsilon[6(p_s^2+1-E_0^2)+6E_0^2(1-\xi^2)-(3E_0^2+p_s^2)(1-\xi^3)-3(1-\xi)]\}, \tag{5}$$

where E_0 is the maximum energy of the electron spectrum, p_s — the impulse of the recoil atom, multiplied by c (E_0 and p_s are expressed in mc^2 units), $\xi=(E_0^2-p_s^2)^{-1}$, ε assumes the same values as in formula (3). For certain values of ε formula (3) is considerably simplified.

In an analogous way with the interaction of the Uhlenbeck-Konopinski type we obtain

$$P(p_s)\,dp_s\sim p_s^2dp_s(E_0^2-p_s^2-1)^4(3E_0^2-p_s^2)(E_0^2-p_s^2)^{-3}. \tag{6}$$

In the most general case the interaction law may be written as a lineary combination of all the possible forms. Then in the case of interaction of the Fermi type the choice of $P(p_s)$ becomes highly arbitrary. If, however, the theory of beta-decay be related to the mesotron theory, as done by Yukawa [5], then the law of interaction of the mesotron field with the light particles will in its most general sense include only the vectorial and tensorial forms of both types of interaction. In Fig. 1 curve I corresponds to the distribution function $P(p_s)$, computed for interaction V_a (1), curve II for V_b, curve III for V_a' or V_b' (2). Thus, if in Yukawa's theory the law of interaction between the field and the light particles contains only terms of the Fermi type, then the distribution function $P(p_s)$ will in the general case have the shape of a linear combination of curves I and II (Fig. 1), i. e. will look different from the case when the interaction law involves but the terms of the Konopinski-Uhlenbeck type (curve III).

Formulae (5) and (6) are obtained, without allowance being made for the influence of the nuclear charge upon the electron spectrum. However, calculations made for an atom with the charge $Z=82$ show the allowance for the charge to be quite inconsiderable. In Fig. 2 dotted curves correspond

to the distribution function $P(p_s)$ computed for interactions V_a (curve I) and V_d (curve II), taking into account the influence of the nuclear charge ($Z=82$), while the solid curves correspond to $P(p_s)$ calculated according

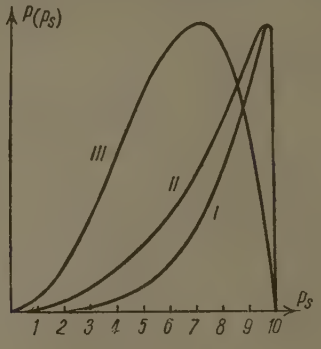

Fig. 1.

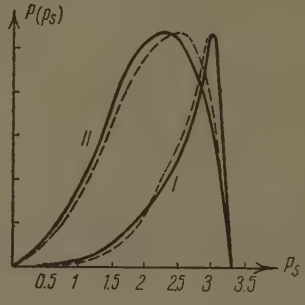

Fig. 2.

to formula (5), i. e. without allowance being made for the nuclear charge.

Hence it may be concluded that the distribution function $P(p_s)$ varies but little with the change in the shape of the spectrum of beta-electrons.

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PHYSICS

METHODS FOR THE INVESTIGATION OF THE STRUCTURE OF ICE

By P. S. VADILO

(Communicated by S. I. Wawilow, Member of the Academy, 22.III.1939)

Up to the present time the structure of ice has been studied with the help of X-rays, with a polarization microscope or else by means of the copying on carbon paper of the «pattern» of ice—the boundaries between the separate monocrystals observable at the bottom surface of a piece of ice. In so far as no ice crystals with well shaped natural faces, such as could be investigated with a goniometer, have hitherto been encountered, the question of the symmetrical appearance of ice crystals remains thus far unsettled.

The application of X-rays in studying the structure of ice is rather complicated. Besides this, the macrostructure of ice cannot be investigated by this method. The use of a polarization microscope is in the present case also very difficult, since the preparation of sections as well as their investigation has to be carried out at temperatures below zero. The main shortcoming of the third method consists in the fact that the pattern obtained on paper is too flimsy and usually tears during the work.

In studying the ice of the Neva river, the writer had resort to the below-described methods for the investigation of the structure of ice which, as it appeared, were free from the above-enumerated drawbacks. The ice-piece under investigation was exposed in damp air, the temperature of which was several degrees above zero. Thereupon the temperature of the air was lowered to some degrees below zero. Under these conditions, on account of sublimation, fine ice crystals were formed over the ice, these crystals being oriented according to the orientation of the crystal axes of that particular section of ice on which they were formed. Thanks to this, the monocrystal sections of the ice-piece and the boundaries between them became clearly identifiable. Every crystal of ice formed through sublimation became covered with faces. By performing measurements of the turning angles of a monocrystalline ice section with which there occurs intensive reflexion of light in the given direction from the faces of one and the same symbol of all the ice crystals, formed by sublimation within the monocrystalline section investigated, it was found possible to determine the symbols of these faces (sometimes so small as to be invisible through a magnifying glass) and even to trace the availability of a mosaic structure in separate ice monocrystals.

Under natural conditions the formation of oriented crystals on ice by means of sublimation takes place every time hoar-frost is formed.

The above-stated method may be applied to the study of the structure of other crystalline substances provided they consist of not too small (mic-

roscopic) crystals. By placing a block of some crystalline matter into the vapours of that same substance (e. g. rock-salt into the vapours of NaCl) or into the vapours of another substance, but such whose crystals form regular concrescences together with the crystals of the substance under consideration, the same phenomenon is obtainable as in ice with the formation of hoar-frost over it. It is only necessary to select the suitable temperature of the vapours, as well as that of the crystal block investigated. In this way it is possible to obtain and to investigate on the same crystal all the faces that are possible for it.

The next method for studying the structure of ice consisted in plotting paper, white side upwards, upon the bottom and side surface of a piece of ice. In result of shading the paper with a black soft pencil with considerable pressure on the latter, distinctly marked boundaries between separate monocrystals of ice become manifest on the paper (since the monocrystals lie lower and the paper over them remains unshaded). On the bottom surface of the piece of ice the boundaries between the separate monocrystals of ice are almost always identifiable, while on the side surface this occurs only in case if the ice-piece be held for a certain time at a temperature slightly above zero, especially with wind. Besides the boundaries between the separate monocrystals of ice, there appear on the shaded paper also lines running over its reverse side, owing to which it is easy to determine the area of every crystal of ice. This method is so sensitive that if the piece of ice is touched with the finger before beginning to pencil the paper, all the slightest details of the finger-print reproduced on ice will also be re-printed on the paper. In case the temperature of air is below zero, it is necessary to warm up the paper a little, previous to removing it from the ice (this can be done by applying the palm of the hand), otherwise it may be torn. The paper may be replaced by some thin textile material.

The boundary between the separate monocrystals of ice can frequently be determined by small bubbles of gas (sometimes extended in the form of tubes of various length) which occur between the separate monocrystals of ice.

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PHYSIQUE TECHNIQUE

SUR LA RÉSISTANCE DU RAYONNEMENT DU VIBRATEUR DE HERTZ

Par A. ARENBERG

(Présenté par W. W. Shoulejkin, de l'Académie, le 15. III. 1939)

1. Il existe deux procédés différents de calcul de la puissance moyenne du rayonnement électro-magnétique (P_Σ) d'un système, défini en temps et espace, et posé de charges et de courants produits par ces dernières. Le premier procédé, nommé habituellement «la méthode du vecteur de Pointing» ($\overline{S}$), définit cette puissance par le flux du vecteur $\overline{S}$ à travers la surface enveloppant le système rayonnant. Le deuxième procédé, dû principalement à L. Brillouin [1] et à I. Kliatzkine [2] et appelé ordinairement «le procédé des forces électromotrices induites», est basé sur la considération des f. é. m. induites dans le système rayonnant sous l'influence de la réaction du champ produit par le système même. Considérons, conformément aux équations de Lorentz [4], le vecteur du champ électrique $\overline{E}$ comme la somme de deux termes

$$\overline{E}_v = -\frac{1}{c}\frac{\partial \overline{A}}{\partial t} \text{ et } \overline{E}_s = -\operatorname{grad}\varphi. \tag{1}$$

Le premier terme ne dépend que du potentiel-vecteur $\overline{A}$ et le second du potentiel scalaire φ. Nous avons pour le vecteur $\overline{S}$:

$$\overline{S} = \frac{c}{4\pi}[\overline{E}_v, \overline{H}] + \frac{c}{4\pi}[\overline{E}_s, \overline{H}] = S_v + S_s, \tag{2}$$

$$\text{où } \overline{H} = \operatorname{rot} \overline{A}.$$

Il est facile à montrer qu'en calculant le rayonnement d'un dipôle élémentaire ayant le moment électrique alternatif [le vibrateur idéalisé de Hertz [3]] par le procédé du vecteur de Pointing, il suffit de se borner à la considération du vecteur $\overline{E}_v$ seul, tandis que si l'on calcule P_Σ par la méthode des f. é. m. induites, il est nécessaire de tenir aussi compte de $\overline{E}_s$.

2. En effet, en dirigeant le dipôle le long de l'axe z afin de simplifier le calcul, nous obtenons la composante radiale du vecteur $\overline{S}_v$ égale à

$$S_{vr} = -\frac{1}{4\pi}\left[\frac{\partial \overline{A}}{\partial t}, \operatorname{rot} \overline{A}\right]_r = -\frac{\cos^2\Theta}{4\pi}\frac{\partial A}{\partial t}\frac{\partial A}{\partial r}, \tag{3}$$

où A est la composante du vecteur $\overline{A}$ suivant l'axe z et Θ — la latitude.

Puis, en introduisant au moyen de la relation $\overline{A}=\frac{1}{c}\frac{\partial \overline{Z}}{\partial t}$ la fonction de Hertz $Z=\frac{f\left(t-\frac{r}{c}\right)}{r}$, nous obtenons:

$$S_{rr}=\frac{\cos^2\Theta}{4\pi c^2}\left[\frac{(f'')^2}{cr^2}+\frac{f'f''}{r^3}\right].$$

Enfin on admet, comme d'habitude, la relation harmonique

$$f\left(t-\frac{r}{c}\right)=M_0\cos(\omega t-kr),$$

où M_0 est l'amplitude du moment électrique du dipôle, ω — la fréquence angulaire et $k=\frac{\omega}{c}$ — le nombre ondulaire, d'où il résulte:

$$S_{vr}=\frac{\omega M_0^2\cos^2\Theta}{4\pi r^2}\left[\frac{k^3}{2}+\frac{k^2}{2}\cos 2(\omega t-kr)+\frac{k^2}{2r}\sin 2(\omega t-kr)\right]. \qquad (4)$$

L'intégration de la valeur moyenne de ce terme sur la sphère d'un rayon arbitraire r, supérieur aux dimensions du dipôle même, nous ramène, après la transition aux unités pratiques, à la formule connue:

$$P_\Sigma=40\pi^2\left(\frac{l}{\lambda}\right)^2 I_0^2 \text{ Watt.} \qquad (5)$$

D'après cette formule la résistance du rayonnement, étant déterminée comme le coefficient de $\frac{I_0^2}{2}$, est égale à

$$R_\Sigma=80\pi^2\left(\frac{l}{\lambda}\right)^2 \text{ Ohm.} \qquad (6)$$

De la même façon on a pour la composante radiale du vecteur $\overline{S}_s$:

$$S_{sr}=-\frac{c}{4\pi}[\text{grad }\varphi, \text{ rot }\overline{A}]_r, \qquad (7)$$

Puis, en partant de la relation entre le potentiel scalaire et la fonction de Hertz, nous obtenons:

$$\varphi=\text{div }\overline{Z}=\left(\frac{f'}{cr^2}+\frac{f}{r^3}\right)z=\Psi z$$

et par conséquent

$$S_{sr}=-\frac{c}{4\pi}\frac{\partial A}{\partial r}\Psi\cos^2\Theta=\frac{\cos^2\Theta}{4\pi}\left[\frac{f''f'}{c^2r^3}+\frac{(f')^2}{cr^4}+\frac{f''f'}{cr^4}+\frac{f'f}{r^5}\right].$$

On a alors pour le cas des oscillations harmoniques du dipôle:

$$S_{sr}=\frac{\omega M_0^2\cos^2\Theta}{4\pi r^2}\left[\frac{k^2}{2r}\sin 2(\omega t-kr)-\frac{k}{r^2}\cos 2(\omega t-kr)-\right.$$
$$\left.-\frac{1}{2r^3}\sin 2(\omega t-kr)\right]. \qquad (8)$$

Il suit de l'expression obtenue que la valeur moyenne de cette composante du vecteur de Pointing est nulle, c'est-à-dire que le vecteur $\overline{E}_s$ ne produit dans la direction r que des flux énergétiques réactifs (déwattés), dont la pulsation a une fréquence double. Si nous prenons la somme des termes S_{rr} et S_{sr}, nous arriverons évidemment aux mêmes résultats qu'on obtient par le procédé classique (5). On obtient de la même façon les expressions des composantes tangentielles du vecteur $\overline{S}$ permettant de faire quelques conclusions nouvelles, dont il sera question plus loin.

Or, il est à noter, que le champ $\overline{E_v}$ a dans les coordonnées cartésiennes des composantes

$$E_{vx}=E_{vy}=0 \text{ et } E_{vz}=-\nabla^2 Z,$$

et le champ $\overline{E}_s$ les composantes *

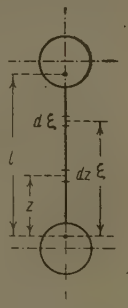
$$E_{sx}=\frac{\partial^2 Z}{\partial x \partial z},\ E_{sy}=\frac{\partial^2 Z}{\partial y \partial z} \text{ et } E_{sz}=\frac{\partial^2 Z}{\partial z^2}.$$

En passant au système des coordonnées sphériques et en substituant la valeur de Z, nous obtenons pour les composantes tangentielles du vecteur $\overline{E}$ les expressions suivantes:

$$E_{v\Theta}=-\frac{\cos\Theta}{c^2 r}f'' \text{ et } E_{s\Theta}=-\frac{\cos\Theta}{r}\left(\frac{f'}{r^2}+\frac{f''}{cr}\right), \tag{9}$$

qui permettent d'obtenir facilement les formules (4) et (8) pour S_{vr} et S_{sr}.

Ainsi, au point de vue de la méthode examinée, ce n'est que la composante $E_{v\Theta}$ produite par le potentiel vecteur $\bar{A}$, proportionnel au courant dans le dipôle, qui peut être considérée comme la composante «actuelle» (pour la détermination de P_Σ) du champ électrique du dipôle**.



Il est important de noter que cette composante $E_{v\Theta}$ décroît en raison inverse de r. Pour les oscillations harmoniques du dipôle, l'expression de $E_{v\Theta}$ peut être réduite à celle connue sous le nom de «formule de la radiation idéale».

3. Considérons à présent la question du rayonnement du vibrateur élémentaire au moyen du procédé des f. é. m. induites. D'après les ouvrages ([1]) et ([2]) cités si-dessus nous trouvons que pour les oscillations harmoniques du vibrateur (figure) (c'est-à-dire quand le courant $i=I_0 \sin \omega t$) ces f. é. m. induites réparties le long du vibrateur sont égales à

$$\left.\begin{aligned} E_{vz} &= -\frac{1}{c}\frac{\partial \overline{A}}{\partial t}=-\frac{\omega I_0}{c^2}\int_0^l \frac{\cos[\omega t - k(\xi - z)]}{\xi - z}\,d\xi \\ \text{et} \\ E_{sz} &= -\frac{\partial \varphi}{\partial z}=\frac{I_0}{\omega}\frac{\partial}{\partial z}\left\{\frac{\cos[\omega t - k(l-z)]}{l-z}-\frac{\cos(\omega t - kz)}{z}\right\} \end{aligned}\right\} \tag{10}$$

où l est la distance entre les centres électriques du système.

Il est évident qu'en calculant la puissance moyenne du rayonnement on ne doit tenir compte que des composantes «actives» (wattées) de ces f. é. m. ***, proportionnelles à $\sin \omega t$ et pour lesquelles on a:

$$\left.\begin{aligned} E_{vz}^{(A)} &= -\frac{\omega I_0 \sin \omega t}{c^2}\int_0^l \frac{\sin k(\xi - z)}{\xi - z}\,d\xi \\ \text{et} \\ E_{sz}^{(A)} &= \frac{I_0 \sin \omega t}{\omega}\frac{\partial}{\partial z}\left[\frac{\sin k(l-z)}{l-z}-\frac{\sin kz}{z}\right]. \end{aligned}\right\} \tag{11}$$

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* Voir aussi chez M. Planck ([6]).

** Notons que M. Becker dans le livre d'Abraham-Becker ([7]) a indiqué qu'il est important de tenir compte du vecteur $\bar{A}$ au point de vue des processus qui ont lieu dans la zone ondulaire.

*** Il sera question des composantes «réactives» (déwattées) des f. é. m., proportionnelles à $\cos \omega t$, dans les publications prochaines.

Puis, en intégrant le long du vibrateur, il n'est pas difficile de démontrer que les amplitudes des composantes actives des f. é. m. dues aux potentiels $\overline{A}$ et φ sont respectivement égales à:

$$\left.\begin{aligned} \mathcal{E}^{(A)}_{vz_0} &= \int_0^l E^{(A)}_{vz_0}\,dz = -\frac{I_0}{c}\left(k^2l^2 - \frac{k^4l^4}{6\cdot 3!} + \frac{k^6l^6}{15\cdot 5!} - \dots\right) \\ \text{et} \\ \mathcal{E}^{(A)}_{sz_0} &= \int_0^l E^{(A)}_{sz_0}\,dz = 2\frac{I_0}{c}\left(\frac{k^2l^2}{3!} - \frac{k^4l^4}{5!} + \frac{k^6l^6}{7!} - \dots\right) \end{aligned}\right\} \quad (12)$$

où $E^{(A)}_{vz_0}$ et $E^{(A)}_{sz_0}$ sont les amplitudes des composantes des f. é. m. $E^{(A)}_{vz}$ et $E^{(A)}_{sz}$.

En partant de ces expressions, nous trouvons que la puissance moyenne du générateur, dépensée sur le rayonnement du vibrateur, est déterminée par les valeurs

$$P_{\Sigma v} = -\frac{I_0\mathcal{E}^{(A)}_{vz_0}}{2} = \frac{I_0^2 R_{\Sigma v}}{2} \text{ et } P_{\Sigma s} = -\frac{I_0\mathcal{E}^{(A)}_{sz_0}}{2} = -\frac{I_0^2 R_{\Sigma s}}{2}, \quad (13)$$

Conformément aux opinions de W. W. Shoulejkin, membre de l'Académie (8), la valeur $P_{\Sigma v}$, due au potentiel vecteur $\overline{A}$, représente la puissance rayonnée par le vibrateur et empruntée au champ magnétique. La valeur $P_{\Sigma s}$, due au potentiel scalaire φ, représente d'autre part la puissance non-absorbée par l'espace et rendue au champ électrique du vibrateur. Or, «la puissance» absorbée par l'espace est déterminée par le terme

$$P_\Sigma = \frac{I_0^2}{2}(R_{\Sigma v} + R_{\Sigma s}),$$

où

$$\left.\begin{aligned} R_{\Sigma v} &= \frac{1}{c}\left(k^2l^2 - \frac{k^4l^4}{6\cdot 3!} + \frac{k^6l^6}{15\cdot 5!} - \dots\right) \\ \text{et} \\ R_{\Sigma s} &= -\frac{2}{c}\left(\frac{k^2l^2}{3!} - \frac{k^4l^4}{5!} + \frac{k^6l^6}{7!} - \dots\right) \end{aligned}\right\} \quad (14)$$

représentent les résistances du rayonnement dues aux potentiels $\overline{A}$ et φ. En nous bornant, étant donnée la valeur minime de kl, aux premiers membres de ces séries, nous obtenons après la transition aux unités pratiques les expressions suivantes:

$$R_{\Sigma v} = 120\pi^2\left(\frac{l}{\lambda}\right)^2 \text{Ohm et } R_{\Sigma v} = -40\pi^2\left(\frac{l}{\lambda}\right)^2 \text{Ohm} \quad (15)$$

dont la somme algébrique nous donne pour R_Σ la formule (6) (voir § 2).

Ainsi on voit que la différence principale de ce résultat et de celui qui a été cité plus haut consiste en ce que lorsqu'on calcule P_Σ (et par conséquent aussi R_Σ) suivant la méthode des f. é. m. induites, on ne peut se borner à considérer que l'influence du potentiel vecteur $\overline{A}$, mais il est indispensable de tenir également compte de l'influence du potentiel scalaire φ; il en résultent des déductions importantes. Les raisons qui sont causes de cette différence, ainsi que quelques autres questions surgissant au cours de la présente étude, exigent de nouvelles recherches dont une partie va être bientôt achevée.

Le sujet de la présente communication nous a été suggéré par W. W. Shoulejkin, de l'Académie, auquel nous sommes bien reconnaissants, particulièrement pour ses précieux conseils et instructions. Une série d'indications nous a été donnée par B. A. Wwedensky, membre correspondant de l'Académie, auquel nous exprimons de même nos remerciements sincères.

Section des Sciences Techniques.
Commission des Communications Électriques.
Académie des Sciences de l'URSS.

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BIOPHYSICS

CONCERNING MY ARTICLE: «SOME REGULARITIES UNDERLYING THE EFFECT OF INDIRECT STIMULI (NEBENREIZ) UPON THE DISCRIMINATION SENSITIVITY OF THE EYE» *

By N. T. FEDOROV

(Communicated by S. I. Wawilow, Member of the Academy, 19. III. 1939)

The scheme of the effect of the indirect stimulus upon irradiation developed by the author finds support in the article by Bilezky and Kravkov (1) who succeeded in obtaining a change in irradiation by a simultaneous effect by a sound stimulus. The increase of irradiation by sound was observed by them (for several observers) when changing the relation of intensities of the bright and dark fields within a very wide range (up to 1 500 000 times).

Only when this ratio was less than 10, did they observe (for the same subjects) the phenomenon of an inverse effect of the sound which did no longer increase, but on the contrary reduced the irradiation.

However, we can by no means believe that irradiation is to be accounted for only by the contrast sensitivity of the eye [see on the subject E. Hering (2), Aubert (3), Wilcox(4), who emphasized the necessity of making allowance for the effect of simultaneous contrast, too, and others]. Therefore it stands to reason that our scheme which refers exclusively to the contrast sensitivity of the eye, can in no way claim to give a quantitative interpretation of the mechanism of this phenomenon and is nothing but a record of the fact observed**. As it may be seen from the very title of the article, we aimed at no explanation of the dependence of irradiation on the contrast between the dark and the light field either.

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* Since one paragraph (last but one on page 73, C.R. Acad. Sci. URSS, XXII, № 2, 1939) of this article was laid down too briefly and not quite exactly, and might thus possibly be misinterpreted, I beg to replace it by the following note. Besides, a misprint should be corrected: in formula (6) for «a» read «a».

** Which has been done in our article in C. R. Acad. Sci. URSS.

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GEOCHEMISTRY

CONTENT OF RARE AND OTHER ELEMENTS IN THE CASSITERITES OF DIFFERENT GENESIS FROM USSR DEPOSITS ACCORDING TO SPECTRUM ANALYSIS DATA

By S. A. BOROVICK and J. D. GOTMAN

(Communicated by A. E. Fersman, Member of the Academy, 15. III. 1939)

Spectrum analysis, as a preliminary stage in the study of mineral resources, often provides a simple answer to a number of questions which arise in the course of geochemical interpretation of the material investigated. Besides, such elements as In, Ga, Ge can generally be detected only by spectrum analysis. The latter possesses, moreover, the additional advantage of requiring for burning in the arc a but very incosiderable amount of material, which can accordingly be selected so as to be of a perfect purity.

There exist only two works where data on the spectrum analysis of USSR cassiterites have been made use of: one by Larionov and Tolmatchev (1), who give data on the spectrum analysis of 7 specimens of cassiterites from Middle Asia, and that by one of the authors (2), where some spectrum analysis data of 9 specimens of cassiterites are given.

The present paper contains data on the spectrum analysis of 27 specimens of cassiterites from USSR tin deposits differing in respect of their genesis. The authors express their aknowledgment to all the persons who provided them with the specimens.

The technique used for obtaining the data given below was as follows: fine grains of cassiterite were introduced into cavities within spectrally pure carbon. The amperage feeding the arc was 8 amperes and the voltage—100 volts.

Three spectrograms were taken for each specimen: the first under the conditions of such a direction of current with which the lower carbon electrode became a negative pole, the cathode layer effect being here used; the second spectrogram was, as usual, taken along the direction of the current when the test-piece served as the positive pole; and lastly, the third spectrogram was taken with the same direction of current, but with longer exposure, so as to make the volatile components of the sample burn out; a sharp rise in the temperature of the arc was observable in this case and the lines of niobium, tantalum, titanium, zirconium and hafnium became more intense. The results obtained by this method are tabulated below.

Symbols used in the table: *—prevailing element; a—lines of high intensity; b—lines of intensity above medium; c—lines of average intensity; d—lines of low intensity; e—lines of very low intensity; f—traces of lines; — —element not detected.

Types of deposits	Pegmatite veins												Quartz and quartz-				
Name of deposits	Kara-su	Zavitinsky		Tchegem	Belliagui-Don	Novo-Durul-guevsky	Urunkhai I specimen 4	Urunkhai II specimen	Verkhne-Bai-Murzinsky	Novo-Durul-guevsky	Imalkinsky	Yultinsky					
		Valley of Sludianka	Main vein									Dark Difference	Light difference				
From whom received	V. I. Krija-novsky	B. M. Kos-sov		P. S. Saa-kian		I. G. Chen-tzov	B. M. Kos-sov	I. G. Chen-tzov	M. F. Strel-kin	K. I. Vis-cont	I. G. Chen-tzov	J. A. Odini-etz & A. G. Shilko					
Colour of cassiterite	Dark brown	Black	Black	Black	Black	Dark brown	Dark brown	Dark brown	Dark brown	Dark brown (spotted)	Light brown	Dark brown	Light brown				
Nb	b	a	a	a	a	a	b	b	b	c	c	c					
Ta	b	c	c	c	c	b	c	b	b	d	—	e					
Be	f	—	—	d	e	d	—	e	—	—	e	—	e				
Cu	—	—	—	—	—	—	—	—	—	—	—	—					
Zn	—	—	—	—	—	—	—	—	—	—	—	—					
Sn	*	*	*	*	*	*	*	*	*	*	*	*	*				
Bi	—	—	—	—	—	f	d	—	—	—	—	—					
Sb	—	—	—	—	—	—	—	—	—	—	—	—					
Pb	—	—	—	—	—	—	—	—	—	—	—	—					
Zr	d	c	c	b	b	b	—	b	b	c	b	c	c				
Hf	—	d	d	—	d	—	—	c	c	—	—	—					
Mo	—	—	—	—	—	—	—	—	f	—	—	—					
V	—	—	—	—	—	—	—	—	—	c	c	f	d				
W	d	—	—	—	e	—	e	e	—	—	—	c					
In	—	—	—	—	—	—	—	f	f	—	—	—					
Ge	—	—	—	—	—	—	—	—	—	—	—	—					
Ga	—	d	—	e	e	d	—	e	f	—	—	—					
Na	—	—	—	d	—	—	—	—	—	—	—	—					
Ca	—	—	—	—	—	—	—	—	—	f	—	—					
Mg	—	—	—	—	f	—	—	f	—	—	—	—					
Cr	—	—	—	—	—	—	—	—	—	d	—	—					
Al	e	e	e	d	e	e	e	e	f	f	f	—	f				
Fe	d	c	d	d	d	b	d	d	d	e	f	e	d				
Mn	c	a	b	b	c	c	c	c	c	e	e	—	—				
Ti	d	c	d	c	c	b	d	c	c	a	a	b	c				
Si	d	d	d	a	d	e	e	d	d	f	d	—	—				

feldspar veins						Sulphide-cassiterite veins								Wood tin		Of unknown genesis	
Kirguiliakh	Bochiisky	Zerensky		Takfon	Zun-Undur	Tarbaldgei	Imtandgea	Haptcheranga		Birsky	Birussa	Nijnaya Ieruda	
		Dark difference	Light difference					Dark difference	Light difference				
M. M. Konstantinov		O. D. Levitzky		J. D. Gotman	J. D. Gotman	E. A. Radkevich	M. M. Konstantinov	A. G. Teremetzkaya		A. K. Voitovich	J. D. Gotman	A. K. Voitovich	
Dark brown (spotted)	Dark brown (spotted)	Dark brown (spotted)	Light yellow	Dark brown (spotted)	Brown (spotted)	Dark brown	Dark brown (spotted)	Dark brown	Honey yellow	Dark brown	Dark brown	Colourless	Colourless, pale yellowish
d	d	d	d	a	d	b	b	d	d	d	c		
c	c			d	c	c	d	b	e	b			
	d					c	d	d	d	a	a		
		f			f	d				f			
										e			
d	d	—	f	f	f	d	e	e	e	f	d	f	d
d	d	f	e	e	d	c	d	d	d	c	d	f	d
			d	d	d	f	d	e		c			
c	c	c	c	a	a	c	a	e	e	d	d	—	d
f	d	f	d	c	f	f	e	e	e	c	d	f	d

In addition to the material represented in the table, it should be stated that the elements Ag, Cd, Co, Ni, K, As, Ba and Sr were not identified in any of the cassiterites under investigation.

The data obtained enable us to point out certain regularities relating to the distribution of admixtures in various cassiterites differing in their genesis.

The cassiterites of pegmatite veins contain enhanced amounts of Nb, Ta, Zr, Fe and Mn; Ga and Be are also very often present in them. This circumstance lends evidential support to the literary data ([1,2]). We must note the existence of Hf in these specimens—a fact which has not yet been mentioned in the literature devoted to the analyses of cassiterites ([1–9]). V does not occur in cassiterites of this type, while W and In are to be found but very seldom.

In the quartz and quartz-feldspar veins, cassiterites are characterized by the availability of V; while Nb, Ta and Fe are to be found less frequently and in lesser amounts; W occurs more often, yet not always; Be, In, Ga and Mn are very rare for the cassiterites of this type; Hf is altogether absent.

The peculiarities of the cassiterites from sulphide-cassiterite deposits are as follows: a rather high content of V as compared with the foregoing type; more frequent presence of W, In and Mn, which are contained in smaller quantities than in the cassiterites from pegmatite veins. It is significant that, according to our data, In must frequently occurs just in the cassiterites from sulphide-cassiterite deposits, as well as in wood tin, and not in the cassiterites from pegmatite veins, as was pointed out by Larionov and Tolmatchev([1]).

As regards the specimens of wood tin, the available material is insufficient for drawing any conclusions. Let us but remark that they contain such elements which are scarcely if at all present in other cassiterites, namely: Zn, Pb, Mo, Sb, Ge.

The last specimens in our table are cassiterites from the placer deposit of Nijnaya Ieruda. They are remarkable by being altogether transparent and colourless. Spectrum analysis has disclosed them to contain only traces of Al, Fe and lines of Si. This shows that the natural compound SnO_2 ought to be colourless, which fact was to be anticipated.

As a general conclusion which can be drawn from the spectrum analysis of our specimens of cassiterites, it may be stated that the cassiterites from pegmatite veins are readily distinguishable from the cassiterites of other deposits, whereas the cassiterites of other deposits differ from one another but slightly.

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Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
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GEOCHEMISTRY

GEOTHERMAL MEASUREMENTS IN MONCHE-TUNDRA

By O. VLADIMIROV, S. KRASKOVSKI and A. SEMENOV

(Communicated by A. E. Fersman, Member of the Academy, 10, III. 1939)

Direct information concerning the thermal regime of the upper strata of the earth's crust is obtained from temperature measurements in drill-holes and workings. Most of these measurements have been made in sedimentary rocks. Very scarce information is available on the distribution of temperatures in crystalline rocks, although these data would be most important to form an idea of the thermal conditions in the earth's crust ([3],[9]).

Geothermal investigations in the region of Monche-Tundra were organized, first, to obtain material, from which one could judge of the temperature distribution in holes drilled in crystalline rocks, and secondly, to check the possibility of applying a thermometer to the determination of the location of sulphide veins.

Temperature measurements were made from April 22 till July 31, 1938, with the aid of a carefully graduated electric resistance thermometer. For greater accuracy, instead of the commonly used three-wire scheme a four-wire scheme was used, the body of the thermometer being directly connected with the source of current. In such a way an almost complete constancy of the current rate was obtained which was highly variable under conditions of crystalline rocks of Monche-Tundra with a three-wire installation. To obtain more reliable results, additional measurements were made by means of a maximum mercury thermometer.

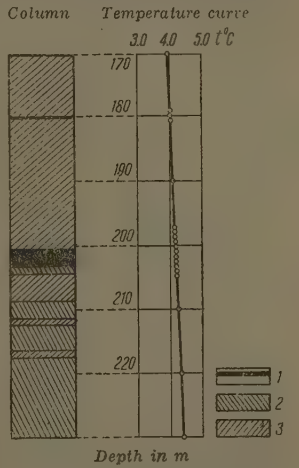

Fig. 1. Depth temperature curve in a bore-hole sunk through a sulphide vein (*1*—sulphide vein, *2*—pyroxenite, *3*—peridotite).

The region of Monche-Tundra is located in the central part of the Kola peninsula, on the western shore of Lake Imandra ($\varphi = 67°45'$ N; $\lambda = 33°$E). The gabbro massif of a NW strike situated within this region, is from the east and south adjoined by piedmonts composed of gneisses of Svionian age, basic and ultrabasic rocks, and rocks of the Imandra-Varzuga series: effusive diabases, tuffogene rocks, schists, amphibolites together with gabbroes, norites and peridotites of Karelian and post-Karelian age. The temperature was measured in prospecting holes drilled on the elevations Nittis, Sopchu-

naivench and Kumujie composed of basic and ultrabasic rocks of Caledonian or pre-Cambrian-post-Karelian age. The depths of the holes ranged from 100 to 450 m with a diameter of 127—85 mm.

To determine the degree of influence of the sulphide veins on the distribution of temperature according to depth, a hole was selected where the conditions for carrying out such an experiment were the most favourable. As will be seen from Fig. 1, the sulphide veins failed to produce any effect upon the distribution of temperature with depth.

A considerable deformation in the distribution of temperature with depth was caused by an inflow of water. As an example, the flowing well No 544 may be pointed to, where the temperature is practically constant from the mouth, through which water is discharged from the rocks, to the surface. In this case we are faced with a fact familiar in the geothermal literature and observed by many investigators to begin with I. Prestwich ([8]). In the rest of the holes no visible disturbances in temperature distribution take place: all of them are characterized by curves in the upper portion, slightly concave towards the axis of depths, and a very acute angle of incline to this axis. In Fig. 2 is given the temperature curve for hole No 572 which is typical of the region of Monche-Tundra.

This bore-hole passed through 4 m of morainic deposits, pyroxenite, peridotite, norite and dioritic gneiss. For the deepest bore-holes (No 572, 226, 98, 216 and 464) the average values of reciprocal gradients have been determined (Table).

Location of hole	Depth, m	t, °C	G, m/°C
Mt. Nittis, 572	100	2.97	144.0
	450	5.40	
» » 226	100	2.45	170.7
	450	4.50	
» » 216	100	3.05	166.6
	300	4.25	
Mt. Sopchuaivench, 98	100	3.05	136.1
	420	5.40	
Mt. Kumujie, 464	100	3.20	140.0
	415	5.45	

It may be seen that the values of reciprocal gradients obtained by measurements are very large. Within the territory of the Soviet Union we know one region where the rise of temperature with depth proceeds very slowly. It is the iron-ore deposit of Krivoy Rog composed of rocks of pre-Cambrian age. The average value of the reciprocal gradient for this region is 112.5 m/°C ([1]).

Outside the Soviet Union there are known several places where the thermal conditions of deep horizons are similar to those of Krivoy Rog and Monche-Tundra. In the pre-Cambrian rocks of Canada near Lake Ontario, in the Porcupine District, R. Cleveland obtained reciprocal gradients from 109. 6 to 122.0 m/°C([9]). In South Africa, at Witwatersrand, and the Kimberley Mine, also in old compact rocks different observers report gradients from 110 to 150 m/°C([6,7]). Finally, in Sweden, in the Boliden Mine, according to the data of Th. Dahlblom, at the depth of 300 m the reciprocal gradient is equal to 77 m/°C([2]).

Our knowledge as to the thermal regime of deep horizons in the regions of crystalline rocks is practically exhausted by these data. But scarce as they are, these data point to a remarkable fact, namely, whenever measure-

ments have been made in old crystalline rocks, very high reciprocal gradients are observed, exceeding the standard value (33 m/°C) three or four times. Whether such thermal conditions are exceptional, anomalous, or else, characterizing the normal value of a thermal stream, generated from the depth of the earth, we are unable to answer definitely, although works by E. E. Van-Orstrand, De-Lury and other American authors throw some light upon this question.

In analyzing the temperature data for Canada and the United States, Van-Orstrand arrives at the conclusion that two types of reciprocal gradients should be distinguished, one for sedimentary rocks (32.9—60.4 m/°C) and the other for undisturbed basement rocks (54.9—109.7 m/°C) ([8]). If in sedimentary rocks the thermal regime is essentially a function of different geological and geochemical processes, in undisturbed areas, however, the gradients, in Van-Orstrand's opinion, «are probably at a minimum and represent a normal gradient in the sense that such a gradient is the result

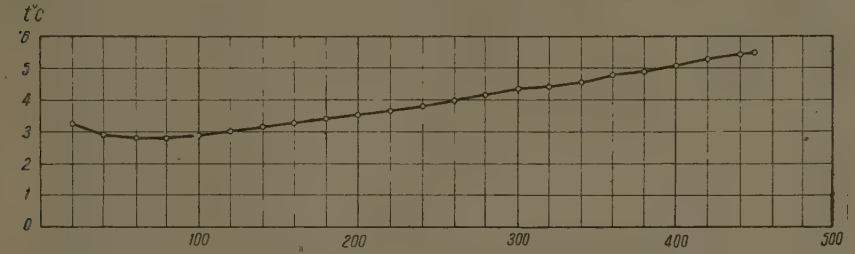

Fig. 2. Depth temperature curve, bore-hole No. 572 (Mt. Nittis, Monche-Tundra).

of an undisturbed flow of heat that began immediately following the solidification of the crust» ([9]).

De-Lury, estimating the normal gradient at less than 109.6 m/°C, arrives at a conclusion that the most reliable data on the thermal conditions of the earth's crust are obtained by making measurements in pre-Cambrian rocks([3],[4]).

If at present we have reasons to believe that the large values of the reciprocal gradients are characteristic of the regions of old crystalline rocks, we hardly have a clear idea of the causes of this phenomenon. Without dwelling on the discussion of the existing hypotheses, let us point out one factor which plays a predominant rôle in the mechanism of heat transmission from the depth of the earth. We mean the physical properties of rocks, their thermal conductivity in particular.

If through the rock with a thermal conductivity K a stationary flow of heat q passes in a vertical direction, the reciprocal gradient G will be equal:

$$G = \frac{K}{q} \cdot 10^{-2}.$$

Hence it follows that with the same flow of heat the reciprocal gradients in different rocks are proportional to their thermal conductivities*.

If, as mentioned above, the reciprocal gradients in old crystalline rocks exceed the so-called «normal» value three or four times, the thermal conductivities of these rocks must have the same ratio. Assuming for sedimentary rocks $K = 20 \cdot 10^{-3}$, and for crystalline rocks $K_1 = 6.0 \cdot 10^{-3}$([5]), we shall have $K_1 : K = 3$.

* This proportionality will be observed only in the case of an infinitely extending horizontal bed.

Consequently, the large reciprocal gradients of Monche-Tundra may to a considerable degree depend on the high thermal conductivity of dense crystalline rocks of this region. Undoubtedly, other causes must be effective in this case too, in the first place the store of cold which has been preserved since the time of the last Quaternary glaciation. Unfortunately, we were unable to determine the thermal coefficients of rocks and to make a more profound analysis of the material collected. It is hoped that this will be done after 1.5 km of the bore-hole which is at present being sunk in Monche-Tundra, have been drilled.

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STRATIGRAPHY

FINDING OF THE MARINE UPPER DEVONIAN AT THE NORTH-WESTERN MARGINS OF THE DONETZ BASIN

By D. NAZARENKO

(Communicated by A. A. Borissiak, Member of the Academy, 23. III. 1939)

Last summer in the course of the investigations of certain dome-like structures of the Artemovsk-Slaviansk trough carried out on behalf of the Institute of Geology of the Ukrainian Academy of Sciences, special attention has been given to the Slaviansk dome-like uplift and in particular to the area of the outcrop of igneous rocks described by N. Preobrazhensky(1). The outcrop of this igneous rock is located in the estuarine part of the left-hand slope of a small woody gulch, opening on the right to the Golaya Dolina river valley, opposite to the northern outskirts of the village Adamovka, about 5 km north-west from Slaviansk. Upon the first examination of the conditions of the outcrop of igneous rock composed of two small blocks, we had the impression that these blocks in no way resembled «veins», as it was suggested by N. Preobrazhensky, being, probably, passive outliers carried out to the surface. This made us effect a small clearing sideways from the outcrop of the blocks which revealed a typical crushed tectonic breccia of dark-grey sheared limestone. Besides these limestones, the breccia proved to be composed also of pale-yellow marly clays with thin broken bands of schistose argillaceous limestones and a band of darker gypsiferous clay. Near the contact of marly clay with crushed limestone there are observed two or three bands of slightly yellow argillaceous limestones and one-two bands of grey limestones with a bluish tinge, non-uniformly (in spots) crystallized, with inclusions of larger calcite crystals. Fauna of fair preservation has been collected in these bands: *Spirifer* ex gr. *Anossofi* Vern. Besides vegetable remains have been detected in the argillaceous limestones which, according to A. N. Krishtofovich, are likely to be stems of *Archaeopteris* (?).

Within the above-mentioned argillaceous portion of the breccia small scaly-cuneiform particles and two larger (1—1.5 m in diameter) blocks of diabase rocks are enclosed, having occasionally a breccia-like structure. The fragments of this rock are intensely and deeply weathered, pierced by calcite veinlets and violently boil with acid. The rock seems to have been subjected to such a deep weathering long before it was carried out on to the surface. At other places of the outcrop of the breccia clearings showed the same argillaceous agglomerate as above described with inclusions of slightly rounded weathered fragments of a coarsely-crystalline pyritized whitish limestone, quite different from the mentioned limestones of the breccia.

Most probably, these limestones, the fragments of which became embedded in the argillaceous agglomerate which constitutes the lower horizons of the rocks composing the breccia, are a more ancient formation, strongly affected by processes of dinamometamorphism. The total thickness of the breccia has not been determined, but it is probably no less than 60—70 m. No traces of pyrometamorphism have been observed and this, together with the above facts, excludes the possibility of interpreting the outcrop of igneous rock as volcanic dyke or vein, as suggested by N. Preobrazhensky. The strike of the breccia is, probably, NO 10° with a dip to the NW at an angle of 85—90°.

The fauna observed (*Sp.* ex gr. *Anossofi* Vern.) is almost exclusively represented by the forms *Spirifer* (*Theodossia*) *tanaicus* mut. *evlanensis* Naliv. (5 specimens), *Sp. katavensis* Naliv. and, possibly, *Sp. katavensis* var *uchthensis* (?) Naliv. The author's determinations of these forms are confirmed by D. V. Nalivkin (²) * and compared with the originals of these forms established by the same author and kept at the Geological Museum of the Central Scientific Research Geological Prospecting Institute. The presence of the above forms in the limestones of the breccia definitely points to their appurtenance to the Frasnian stage of the Upper Devonian.

It will be of interest to note that among the above forms are present representatives of the Upper Devonian fauna of the South Urals (*Sp. katavensis* Naliv.) and, possibly, those of the Timan (*Sp. katavensis* var. *uchtensis* Naliv.); prevalent is the form (*Sp. tanaicus* mut. *evlanensis* Naliv.) characteristic of the Evlan beds of the Voronezh Devonian. D. V. Nalivkin gave lately this form, owing to its stratigraphic importance, the rank of an independent species—*Sp. evlanensis* Naliv. (private information). It should be noted, moreover, that the composition of the breccia of the Devonian rocks of the Slaviansk dome, as well as the composition of the fauna as a whole, resemble very much the fauna and the breccia of the Issachki salt plug in the Lubny region of the Ukrainian Socialist Soviet Republic. Strikingly similar are also the tectonic conditions of the outcrop of breccia of both regions, hence one may assume that common causes are responsible for their appearance at the surface.

It is known that the tectonic breccia of the Devonian rocks at Issachki was brought out chiefly owing to the salt tectonics; the salt stocks passively brought out both the breccia and huge blocks of diabase in the form of scales or a «cap» which had been predicted by N. S. Shatsky (³). The bringing out of the breccia to the surface in the area of the village of Adamovka have not been as yet accounted for in this way; nevertheless the similarity and the age of these formations, as well as the relative analogy of the conditions under which they appeared at the surface in both regions, lead us to the conclusion that the breccia of the region of the village of Adamovka might have been brought out by a salt stock, as this was the case at Issachki and Romny. This is consistent with the general dome-like character of the tectonics of the north-western marginal parts of the Donetz basin. If such a viewpoint be accepted, it is to be assumed that aside from the Lower Permian salt a second horizon of saliniferous rocks, lying stratigraphically below the rocks of the Fransian stage, exists in the north-western marginal parts of the Donetz basin. It is to this saliniferous horizon that the dome-like structures of the north-western marginal parts of the Donetz ridge are due, since the Permian saliniferous beds are absent almost in all the dome-like structures of these regions and are arranged at their periphery and in the spaces

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* The author wishes to take this opportunity to express his sincere gratitute to Prof. D. V. Nalivkin who kindly undertook the task of examining the above fauna.

between the domes*. It stands to reason that to support or refute such an assumption test boring is necessary; aside from theoretical interest, the latter may yield important practical results.

The finding of a breccia of Devonian rocks in the region of the Slaviansk dome permits of tracing a more definite link between the tectonics of the north-western marginal parts of the Donetz ridge and the structure of the Dnieper-Donetz depression. In author's opinion, this relation is observed in the following tectonic directions:

1. The northern tectonic line—Lisichansk-Kremennaya-Volchansk in the region of the Staroverovsk station and the village of Novo-Nikolaevka (westward from the town of Kupiansk it is manifested by a local partial absence from sections of the Paleogene of the Buchak and Kiev stages).

2. The middle chief tectogenic line at the north-western marginal parts is composed of the Drujkov-Konstantinov-Korul-Petrovsk and the Dranov-Krasny Oskol directions drawing together north-westward from Izyum and proceeding further in the directions of Akhtyrka (somewhat further to the west), Gadyach, Romny, Talalaevka, Dmitrievka and Chernigov.

3. The southern line which is the continuation of the southern anticline of the Donetz ridge, proceeds from the latter through the outcrops of the Middle Carboniferous along the Solenaya and Byk rivers in the direction of Pereschchepino, Poltava, Mirgorod, Issachki, Pozniaki and, possibly, turns even towards Chernigov approaching the second line. At the junctions of these lines dome-like structures and diapir breaks are developed.

The Slaviansk dome is a secondary intermediate structure developed under the action of tectonic stresses which proceeded from the above tectonic directions approaching each other along the northern anticline of the Donetz ridge. It is typical that in the zones of these approaches disjunctive dislocations are developed accompanied by the appearance of breccia (the Petrovsk dome).

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* The development and ultimate formation of dome-like structures took place on the basis of the plicative forms of tectogenesis, producing the upward movement of salt stocks; all the disjunctive forms of disturbances were the result of expansions in the roof of the stock.

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BIOLOGY

SELECTION AS A FACTOR ALTERING THE DEPENDENCE OF CHARACTERS ON VARIATION IN ENVIRONMENTAL CONDITIONS

By M. M. KAMSHILOV

(Communicated by I. I. Schmalhausen, Member of the Academy, 22. III. 1939)

After Roux ([7]) had discriminated between self-differentiation, dependent differentiation and passive differentiation, the terms «dependent character» and «independent character» became firmly adopted by biology. Roux himself identified independent or self-differentiating characters as hereditary characters in contrast to dependent or non-hereditary characters. These Roux's ideas, in a slightly modified form, it is true, were adopted by modern genetics. Siemens ([8]) introduces the term «paratype» to comprise the total of characters depending on environmental factors; to designate hereditary factors he offers the term «idiotype».

Wright ([12], [13]) follows Siemens while stating: «characteristics differ greatly in the extent, to which they are determined by heredity. Some, like most coat colours, are almost wholly hereditary. Others, like fertility and length of life, are largely environmental» ([13]).

The idea of the organism being composed of genotypical and paratypical characters was subjected to severe criticism by a number of investigators. We find such a criticism in a clear form in Johannsen's work([3]). He was fully justified in pointing to the fallibility of such an idea, since all the characters depend on both genotype and surrounding medium.

The erroneous idea of the organism being composed of hereditary and non-hereditary elements comes from the confusion of two distinct problems, viz., (I) question on the genotypic determination of characters and (2) question on variability of characters under the influence of surroundings.

The first question should be answered positively in respect to all the characters. All the characters depend on both genotype and surroundings. This means that all the characters of an organism arise as a result of its development under definite conditions.

The second question should be answered differently according to the kind of organism and character under investigation.

Not all the characters are equally changed with the change of external conditions. This should not, however, be taken to mean that highly variable characters are not determined genotypically. Milk production, body weight and a number of like characters just belong into the category of characters which greatly vary with the variation of external conditions; however, for every form of manifestation of these characters there is a base in the genotype. In other words, each of them arises during the process of development under definite conditions. Characters, like eye colour, number of extre-

mities etc., belong into a less variable category. It does not mean, however, that they develop independently of the surrounding medium. Organisms cannot develop in absence of food, oxygen, beyond certain limits of temperature, and this merely means that all the characters more or less directly depend in their development on the surrounding agencies. From this viewpoint, when discussing «dependent» or «independent» characters, one should merely think of characters which are more dependent or less dependent in their development on changes in surrounding medium [see also Schmalhausen(14)].

A question also arises as to the extent to which «dependence» or «independence» of a character on external conditions is correlated with its origin in the course of natural or artificial selection which occurred for this character. To clear up this question we have conducted several series of experiments in selection for maximum expression of the mutual character *eyeless* (absence of eyes) in *D. melanogaster* under various conditions. T. Morgan (6) has most clearly shown that this character is differently expressed at the beginning and at the end of hatching in connexions with changes occurring in the food (mainly decrease in moisture). The character thus exhibited a quite definite dependence on changes in external agencies.

Selection was conducted, on the one hand, for maximum expression of eyeless among individuals which hatched first (series № 1 and № 1A), the expression of the character being also studied on the last days. On the other hand, individuals hatching last were selected for maximum expression of eyeless (series № 2 and № J2), the expression of the character on the first days being also checked. The technique of selection was described in our 1935 paper (4).

The proportion of eyeless has rather significantly increased in all the four series as a result of selection. We are interested here, however, not in the percentage of the selected character, but in the ratio of the expression on last days of hatching to that on the first days of hatching (designated later II/I).

The table represents the results of the experiments. The data of those series where selection was conducted on first days of hatching (№ 1 and 1A), are on the left, on the right are the data of series № 2 and № J2, where selection was done on the last days.

Selection on the first days				Selection on the last days			
№ 1		№ 1A		№ 2		№ J2	
Generations	II/I	Generations	II/I	Generations	II/I	Generations	II/I
1—5	0.785	1—5	0.318	1— 5	0.625	1— 3	0.321
6—10	0.810	6—10	0.373	6—10	1.040	4— 6	0.548
11—15	0.688	11—15	0.438	11—15	1.371	7— 9	0.724
16—20	0.515	16—20	0.652	16—17	1.520	10—12	0.915
21—24	0.548	21—25	0.604			13—15	1.030
		21—29	0.497				

Column II/I contains the ratios of the expression of eyeless on the last days of hatching to that on the first days. The data relate not to individual generations, but are summarized for several generations (see the column «generations»). This allows to eliminate accidental errors.

It is characteristic of the mutation eyeless that the value II/I is always below 1.0. In other words, the expression of eyeless on the last days is always

slighter than on the first days. When selection is conducted on the first days of hatching, in series № 1 and № 1A no fundamental changes take place. The value II/I remains below 1.0 (table).

An entirely different situation results from selection practised on the last days (table). In the two series (№ 2 and № J2) value II/I gradually increases to exceed 1.0. This means that the expression on the last days of hatching becomes stronger than on the first days. In other words, when selection is conducted on the last days of hatching, the kind of dependence of the character eyeless on environmental fluctuations changes.

The fundamental similarity between the series № 2 and № J2, on the one hand, and series № 1 and № 1A, on the other, as well as fundamental difference between the data of series № 2 and № J2 from those of series № 1 and № 1A, excludes explanation of the results obtained by accidents of the kind of genetico-automatic processes (2).

It appears thus possible to change by selection the kind of dependence of the characters on variation in environmental conditions. Character which depends in the expression on the time of hatching (more precisely, on the moisture content of the food) may be transformed into an independent one (II/I=1). Even more than this, the very kind of relation may be altered: the expression on the last days of hatching (i. e. when development proceeds in dried up food) may be made higher than that on the first days.

It is of interest that in our experiment alteration of the dependence of the character on fluctuation of the external conditions (№ 2) passes through three phases: at the beginning the character is clearly dependent, the expression being stronger on the first days than on the last ones; then the character becomes independent, and finally, it becomes dependent again, but the dependence changes its sign to the opposite. Independence of the character in our case appears to be merely one of the moments of the variations in the kind of dependence.

Organisms with similar genotypes develop differently under different conditions. We speak of modifications. However, the kind of this variation is far from being accidental, it is genotypically determined in a similar manner; thus, the change in dependence of eyeless on environmental conditions undoubtedly characterizes in our case the new genotype which arose as a result of selection.

Baur (1) wrote as early as in 1911: «Ein «Angepasstsein» eines Organismus besteht nicht in einer bestimmten Form, Farbe, Struktur u. s. w., sondern immer nur darin, dass er durch die Aussenbedingungen, unter denen er lebt, in vorteilhafter Weise modifizierbar ist. Wenn wir also fragen und erklären wollen, wie die vorteilhaften Eigenschaften der Organismen entstanden sind, so lautet im Grunde genommen die Frage immer: Wie ist die vorteilhafte Modifizierbarkeit entstanden?» (p. 262, spaced by Baur).

He writes further that the origin of such an adaptive modification may be explained only on the basis of Darwin's principle of selection. This statement has found its partial development in the work by Kirpichnikov (5). Kirpichnikov similarly considers non-hereditary variation as being an expression of organic adaptation to the surrounding medium. Still greater development of these ideas is contained in the book by Schmalhausen (14).

Vavilov (11) has pointed to the importance of non-hereditary variation for plant breeding, All these considerations are correct only in the cases when changes of the kind of dependence of characters on the fluctuation of external conditions take place in the course of selection under definite condi-

tions. When dependence of the character on the fluctuation of the external conditions can be changed by selection, and our experiments support such a possibility, a correlation should naturally arise which would guarantee better survival of the species under fluctuating developmental conditions. Non-adaptive modification would gradually become adaptive.

A brilliant example is offered by polymorphism within a colony of ants connected with differences in nutrition; it was cited by H. Spencer ([10]) as evidence of inheritance of acquired characters. As a matter of fact, however, this instance is a good evidence for the rôle played by selection in creation of adaptive modificatory variability. More simple instances are the reaction of a muscle to work, reaction of plants to humidity and drought, etc.

Evidently, there are many ways of evolution of the dependence of a character on fluctuation of external conditions. We shall point only to some of them. 1) In our case an especially strong change in dependence of expression of eyeless occurred in cases of selection on the last days of hatching, i. e. under the conditions of least expression. It is quite obvious that during selection for maximum expression of a character under certain definite conditions when there is no complete correlation among expressions of various genotypical characteristics under different conditions, the character would gradually become strongly expressed just under these particular conditions. In case it was less expressed under these conditions as compared to others, its variation would pass the phases of independence of fluctuations of these conditions, as it was the case in our experiments. 2) Selection for a definite degree of expression under changing conditions of development would, as a rule, lead to an increase of independence of the character of fluctuations of external conditions, since it is the similarity of expression under various conditions which is being selected for. In case we attempted selection for maximum or minimum expression of eyeless on the first or on the last days of hatching, we obviously would obtain either complete expression or complete non-expression in both kinds of conditions. The conditions of selection, their greater or lower constancy thus also influence the evolution of the dependence of the character on the fluctuations of the medium. It is known from the breeding practice that a greater or lesser constancy of the characters of a variety often depends on the conditions under which it had arisen. Strong climatic fluctuations produce, as a rule, more universal varieties which are more constant under changing conditions of development. Regions with milder and even climate, on the contrary, give birth to varieties possessing opposite characteristics. Examples of such dependence are found in the works by Vavilov ([11]) and Sinskaja ([9]).

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GENETICS

A DOMINANT MUTABLE GENE FOR PURPLE COLOUR IN THE *R* SERIES OF MULTIPLE ALLELOMORPHS IN MAIZE

By M. I. HADJINOV

(Communicated by N. I. Vavilov, Member of the Academy, 3.III.1939)

Although maize has been subjected to a quite thorough genetic study, over 400 genes having been described in this plant, there has been known only one frequently mutating gene P^{vv} for variegated pericarp (1). The new frequently mutating gene described below, for purple plant colour, was discovered in isolated maize plants from Central Mexico.

The character manifests itself from the moment the seedlings make their first appearance. In mature plants purple colour of different degrees of intensity may appear in all parts exposed to light, except in anthers which, unless special genes are present in the heterozygotes, are green in colour. Beginning with the first leaf and ending with the branches of the tassel, separate sectors of the outer tissue may change colour to green. As a rule, the narrow, longitudinal green stripes appearing on the lower leaves become broader on succeeding leaves or else their number may increase, so that, after 4 to 10 leaves have developed, they prove to have completely supplanted the coloured tissue. When a narrow green stripe has appeared on a leaf, only in very rare cases it is absent on the next one. The tassel may be solid purple, to a variable degree chimeral, or green. When there are several pistillate inflorescences on a plant, the colour of their silks may differ. More rarely the silks of a single inflorescence may be chimeral as to colour.

The rate of replacement of the purple tissue by the green one varies in different plants, being connected both with their heterozygosity for this character and with unknown individual differences between the plants. The colour is well expressed on growing parts of the plant; on older parts it is considerably less intense.

A study of the nature of the inheritance of this character was made on the progeny of three plants obtained from one family as a result of three generations of self-pollination of the progeny of an original open-pollinated plant with purple colour.

In the progeny of the three original plants taken for study segregation as to colour at the seedling stage was as follows. Plant A had 89.1% purple seedlings (total number of seedlings 92); plant B—92.1% (114), and plant C—76.7% (60). In classifying self- or cross-pollinated mature plants as belonging to the group of purple-coloured plants, we included both those solid purple and striped plants having purple silks and tassels. Into the group of green plants we included plants solid green from the seedling stage, those becoming green prior to the setting of the ears, and, lastly, striped

plants having green silks and tassels. In the progeny of these three plants a number of purple and green plants were self- and cross-pollinated; in the case of some plants it was possible to do this simultaneously. Green plants for hybridization with purple plants were taken both from the same progenies and from other genetic cultures. Colour analyses of the crosses and self-pollinations were made, in order to reduce the scale of the experiment, only at the seedling stage.

In the group of green plants in these three progenies 9 were self-pollinated and 7 were crossed with other green plants in one or the other direction. In the progenies from these self-pollinations and crosses there were studied 213 and 118 plants respectively which all proved to be green. The results for the group of purple plants are given in Table 1.

Table 1

Plant №	Self-pollination		F_1 ♀ purple × ♂ green		F_1 ♀ green × ♂ purple		Plant №	Self-pollination		F_1 ♀ purple × ♂ green		F_1 ♀ green × ♂ purple	
	Purple plants (in %)	Total № of plants	Purple plants (in %)	Total № of plants	Purple plants (in %)	Total № of plants		Purple plants (in %)	Total № of plants	Purple plants (in %)	Total № of plants	Purple plants (in %)	Total № of plants
A							B						
2	—	—	0.0	25	0.0	130	12	87.6	105	75.6	41	81.8	22
3	—	—	23.1	26	0.0	107	18	61.9	63	—	—	—	—
4	—	—	78.8	52	—	—	19	—	—	50.0	30	—	—
5	90.5	109	—	—	50.0	36	28	89.2	37	—	—	—	—
7	66.7	66	—	—	38.9	36	45	92.2	51	—	—	—	—
13	—	—	47.4	19	—	—	51	100	9	70.6	34	—	—
14	0.0	157	—	—	0.0	70	54	—	—	57.1	35	73.3	15
24	—	—	96.3	219	—	—	55	59.0	117	42.8	7	33.3	39
35	—	—	—	—	0.0	54	57	52.2	67	—	—	22.2	9
35	—	—	—	—	10.8	74	59	100	21	—	—	—	—
37	—	—	37.5	18	—	—	C						
38	—	—	0.0	19	—	—	7	61.5	13	—	—	—	—
41	71.3	101	59.1	164	—	—	17	67.3	52	—	—	—	—
59	—	—	0.0	86	—	—	25	—	—	31.6	19	—	—
63	9.2	76	—	—	—	—	28	—	—	46.4	28	21.7	138
93	—	—	70.8	48	—	—	30	—	—	—	—	70.0	10
96	—	—	0.0	18	—	—	34	73.3	36	—	—	—	—
96	—	—	56.3	16	—	—	36	79.4	59	—	—	—	—
							42	—	—	—	—	70.6	68

The quantitative relations obtained in the progeny are most diverse. However, if for the time being we exclude cases of the entire absence of purple seedlings in the progeny of occasional plants, the explanation of which we shall discuss later, it may be presumed that purple plant colour is due chiefly to one dominant gene. Its action is complicated by its mutability, which results in lack of genetic uniformity in certain portions of the soma and gametes. This is shown by several facts. In crosses, in which the pollen was taken separately from chimerally coloured and solid purple branches of the same tassel, the F_1 results were quite different. One of such crosses is included in Table 1 (cross with A-35) where the percentage of purple seedlings in F_1 amounted to 0.0 and 10.8 respectively. In another case the pollination of two plants of the same homozygous green family with pollen from chimerally coloured and solid purple parts of a tassel gave, respectively, in F_1 2 purple plants out of 42 (4.8%) and 12 purple out of 19 (63.2%). Results differed also when different ears of the same purple plant were crossed with different green paternal plants (crosses with A-96). Lastly, cases of diffe-

rences between direct and reciprocal crosses between one and the same purple and green plants (crosses with A-3, B-54, and C-28) confirm the non-uniformity of gametic composition in different inflorescences and their parts. The considerable mutability of this dominant gene for purple colour results in a number of cases in deviations from simple Mendelian ratios.

In the F_2 we studied 11 combinations of crosses between purple plants of the families A, B and C and green plants of other genetic cultures, both direct and reciprocal. By self-pollination of 23 green F_1 plants there were obtained 1124 F_2 plants, all but five of which were green. These five purple plants may have appeared as a result either of contamination during self-pollination or of repeated mutations.

The behaviour of purple F_1 and F_2 plants is the same as that of such plants in the initial families. Data showing this are presented in Table 2. The number of purple plants approximates only in a few F_2 families the number theoretically expected in monohybrid segregation; usually it is considerably less, and sometimes there is a complete absence of purple plants. The latter circumstance may be ascribed to the periclinal structure of such plants (2) resulting from the lack of synchronism of the mutation process in epidermal and sub-epidermal layers. Chimeral colouring of inflorescences usually results, in case of either cross- or self-pollination, in the complete absence of purple colour in the progeny. Only from two out of six crosses, in which the paternal form had a tassel chimeral as to colour, did we succeed in getting a small percentage of purple seedlings in the progeny. Only green seedlings resulted in the three cases where ears with silk chimeral as regards colour were pollinated with pollen from green plants.

In F_2 families which segregated with respect to both plant and aleurone colour (gene R)—crosses: 594 (A_1Cr^{gg})×B-12 (A_1CR^{pg}) and 594 (A_1Cr^{gg})× ×C-28 (A_1CR^{pg})—there exists close correlation between aleurone and plant

Table 2

F_1, Pedigree №	Genotype of green parent	F_1, Pedigree №	Colour of self- and cross-pollinated F_1 plants	№ of F_2 plants		Purple plants (in %)
				Purple	Green	
A-3 × 528 . . .	a_1R^{gg}	540—37 ⊙*	37 purple	6	19	36.0
B-19 × 591 . . .	»	551—21 ⊙	21 »	60	90	40.0
B-54 × 591 . . .	»	556—32 × —4	32 green; 4 purple	4	21	16.0
B-54 × 591 . . .	»	556— 1 × —4	1 purple; 4 »	19	32	37.3
597 × B-54 . . .	a_1r^{rr}	557—12 ⊙	12 purple	11	89	11.0
B-51 × 592 . . .	A_1R^{gg}	558— 1 ⊙	1 »	15	54	21.8
B-51 × 592 . . .	»	558—17 ⊙	17 »	0	67	0.0
B-51 × 592 . . .	»	558—30 ⊙	30 »	33	22	60.0
B-51 × 592 . . .	»	558—33 ⊙	33 »	14	52	21.2
594 × B-12 . . .	A_1r^{gg}	560—60 ⊙	6 »	76	274	21.8
594 × B-12 . . .	»	560— 3 × —5	3 purple; 5 green	28	58	32.6
594 × B-12 . . .	»	560—26 × —8	26 » 8 »	151	205	42.4
594 × B-12 . . .	»	560—18 × —16	18 green; 16 purple	196	185	51.5
594 × B-12 . . .	»	560—30 ⊙	30 purple	152	88	63.3
Reciprocal cross .	»	561—44 ⊙	44 »	88	143	38.1
» » .	»	561—49 ⊙	49 »	3(?)	93	3.1
594 × C-28 . . .	»	566—29 × —21	29 purple; 21 purple	58	112	34.1
Reciprocal cross .	»	567—29 × —26	29 green; 26 »	18	119	13.1
» » .	»	567—21 × —14	21 purple; 14 green	144	213	40.4
» « .	»	567— 3 × —16	3 » 16 »	63	178	26.2

* ⊙—self-pollination.

colour. In seven families from these two crosses in the progeny of kernels with coloured aleurone 773 out of 1324 plants, i. e. 58.4%, were purple-coloured at the seedling stage, while from kernels with colourless aleurone only 4 out of 464 plants (0.9%) were purple. To refer the gene for purple plant colour to the *R* series of multiple allelomorphs, in the class of kernels with colourless aleurone there should not be a single purple plant. Their occurrence may be ascribed to the phenomenon of «hetero-fertilization» ([3]) (the participation in fertilization of sperms from two pollen grains of different genotypic constitution which results in the endosperm and embryo being of unlike genotypic composition) or to possible reverse mutations.

The data now at hand we consider sufficient to refer this new gene to the *R* series of multiple allelomorphs ([4]), calling it R^{pg} (purple with green anthers). In this series it occupies a dominant position with respect to plant colour over all the other members of the series, but a recessive position with respect to anther colour. The gene R^{pg} mutates only to R^{gg} (green with green anthers), a recessive allelomorph, the order of dominance with respect to plant colour being R^{pg}, r^{ch}, R^{rr}, R^{rg}, R^{gg}. All these allelomorphs, except R^{pg}, may with equal foundation be regarded as normal «wild» allelomorphs, since they occur quite frequently in aboriginal forms of American maize.

The mutation rate of the gene R^{pg} is very high. According to preliminary calculations, among heterozygotes as many as 90% of the plants sooner or later become striped or entirely green. Due to the high rate of somatic mutations, it is very difficult to determine the mutation rate during gonogenesis in heterozygotes. In the case of conditional homozygotes (plants giving, when backcrossed, more than 50% purple seedlings), by using them as mother plants and provided that the seeds which give rise to green seedlings are borne at random on the ear, one can judge with some assurance as to the probable mutation rate in gonogenesis. Two such crosses (with A-24 and A-41) gave a mutation rate in the gametes of 3.7 and 40.9%. However, it was not possible by this method to elucidate fully the highest limit of mutability in gametes of homozygotes.

The case here described is of interest in the following respects:

1. The dominant gene R^{pg} represents a comparatively rare example of a gene with an exceptionally high mutability exhibited to a considerable degree during all stages of ontogeny.

2. The behaviour of the great majority of known mutable genes indicates that their transformation proceeds from a mutant recessive to a normal dominant and relatively more stable gene ([5]). The gene R^{pg}, being a dominant mutant with respect to most of the allelomorphs of the *R* series, mutates to R^{gg}, a normal recessive allelomorph of the same series. Hence, in this case it is shown that the transformation of a mutable gene from an unstable to a relatively more stable member of an allelomorphic series is not connected with the dominance or recessiveness of the mutable gene.

3. A third fact of particular interest is that the mutable genes now known in maize—P^{rv} and R^{pg}, as well as the recently described case of the conversion of a stable gene a_1 into an unstable one in the presence of a specific gene *Dt* ([6]), all belong to big series of multiple allelomorphs—*P*, *R* and A_1—which, apparently, points to the instability of these allelomorphs.

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AGROPHYSIOLOGY

DROUGHT RESISTANCE OF SPRING WHEATS IN VARIOUS PERIODS OF FORMATION OF VEGETATIVE AND REPRODUCTIVE ORGANS

By G. V. ZABLUDA

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From our studying how the formation of reproductive organs proceeds through different stages of development and how it is affected by drought, we inclined to the opinion that the principle reason which may be put forward to account for the highly variable and sometimes conflicting results obtained by different investigators respecting the drought resistance of

Structure and Yield of Wheats which Had Suffered

Variety	Elimination of water supply	Return of irrigation	Periods of formation of vegetative and reproductive organs during drought	Number of spike-bearing stems per pot		Number of spikelets per spike		Number of underdeveloped and sterile spikelets per spike	
				Main	Lateral	Main stem	Lateral stem	Main stem	Lateral stem
Milturum 0321	—	—	Control	5	16.2	18.8	17.6	1.4	3.5
	23.V	5.VI	Formation of leaves . . .	5	14.0	13.6	16.2	0.3	3.2
	3.VI	15.VI	Formation of leaves and increase in length of stem growing cone	5	18.2	13.5	14.5	0.8	2.8
	13.VI	25.VI	Formation of spikelets . .	5	17.2	17.3	15.4	1.8	3.7
	25.VI	5.VII	Formation of florets . . .	5	14.8	19.0	17.2	3.4	4.5
	5.VII	15.VII	Formation of sexual cells .	5	12.0	19.0	16.1	5.3	8.3
Lutescens 062	—	—	Control	5	12.0	16.3	15.8	0.8	1.8
	23.V	5.VI	Formation of leaves . . .	5	11.4	10.2	13.3	0.1	1.3
	3.VI	15.VI	Formation ot spikelets . .	5	15.4	13.5	12.7	0.6	1.4
	13.VI	23.VI	Formation of florets . . .	5	15.6	16.5	14.8	1.0	2.7
	23.VI	13.VII	Formation of sexual cells .	5	13.0	15.9	12.7	4.2	4.0
	5.VII	15.VII	Formation of grain	5	12.0	16.5	15.4	1.0	1.8

wheat at the period of tillering, is that during this stage the formation of reproductive organs proceeds differently in different varieties, and within one variety is dependent upon the conditions of growing.

In order to verify this supposition we started experiments with two varieties of spring wheat: *Lutescens* 062 (early), *Milturum* 0321 (late). Germinated seeds were planted May 13 into earthen pots, of 3.5 kg abs. dry soil capacity. A half-dose of Hellriegel's medium was introduced after planting. 5 plants were growing in each container. Every day the moisture of soil was made up to 65% of total moisture capacity. Drought was created by cutting the water supply in the following periods of development. Formation of : (1) leaves, (2) spikelets, (3) florets, (4) sexual cells, (5) grain. Water was withheld from the plants for 10—12 days. Wilting lasted 5—6 days. When drought was expiring there was always 16—18% of water left in container, the one and half maximum hygroscopicity being 14.2%.

In the early variety 062 tillering began May 28 and ended June 15, i. e. lasted 18 days. The respective dates for the late variety are May 30 and June 30 with the total duration of 31 days. The formation of spikelets commenced on June 3 (June 13) and was completed on June 15 (June 25) in the early (and late) variety respectively. In other words, the varieties tested differed in the duration of tillering, but were forming spikelets during an equal number of days, whereby the variety 062 had it spikelets already formed when this process started in the variety 0321.

Accordingly, the processes of floret and sexual cell formation were also delayed in the late variety, though they lasted the same number of days as in the early one. Add to this that the seedlings of both varieties appeared above ground May 16, and it will be obvious that a later outset of reproduc-

Soil Drought in Various Periods of Development

Number of grains per spike		Number of grains per spikelets		Weight of grain per pot in g				Weight of one kernel in mg		Weight of straw and chaff per pot in g	
Main stem	Lateral stem	Main stem	Lateral stem	Main stem	Lateral stem	Total in g	Total in %	Absolute	%	Absolute	%
44.9	30.0	2.6	2.1	7.2	14.6	21.8	100	30.7	100	31.4	100
40.2	28.1	3.0	2.2	6.5	11.9	18.4	84.4	30.9	100.6	26.1	83.1
38.3	26.2	3.0	2.2	6.1	14.5	20.6	94.5	30.8	100.3	29.7	94.6
37.8	27.6	2.4	2.3	5.7	14.2	19.9	91.3	30.0	97.7	25.6	81.5
30.6	24.8	2.0	1.9	5.1	10.0	15.1	69.3	27.5	89.5	22.0	70.0
23.3	11.7	1.8	1.5	3.7	3.3	7.0	32.1	27.4	89.2	21.4	68.1
45.0	31.0	2.9	2.2	8.6	13.2	21.8	100	36.5	100	26.5	100
28.9	26.0	2.9	2.2	4.9	12.9	17.8	81.6	35.8	98.1	24.7	93.2
32.6	25.1	2.5	2.2	6.2	14.3	20.5	94.0	37.1	101.6	27.4	103.4
36.0	20.6	2.3	1.7	6.4	9.9	16.3	74.7	33.1	90.6	20.7	78.1
20.6	14.2	1.8	1.6	4.1	4.8	8.9	40.8	30.9	84.6	19.4	73.2
43.0	28.0	2.8	2.0	5.3	8.3	13.6	62.4	24.7	67.6	23.9	90.2

tive organ formation in the variety 0321 is due to a longer duration of the period when leaves were forming in it. The result was that 062 had only 7 leaves on the main stem, while in 0321 their number was 9. The number of spike-bearing stems per pot was respectively 12.0 (in 062) and 16.2 (in 0321). An interesting point to note here is that in 0321 the increase in length of the stem growing cone became apparent June 3, while the spikelet tubercles appeared only June 13. These dates, however, were pressed closely together in the variety 062, in which the growing cone started visible lengthening June 2, and a day later (June 3) there were already appearing spikelet tubercles.

When the data obtained from the observation of how the vegetative and reproductive organs were forming during drought are compared to those referring to the structure and yield (table), it is apparent that both of the varieties studied are fairly plastic as regards the direction, in which the formation of vegetative and reproductive organs is apt to proceed after drought has exerted its influence.

The yield is reduced in varying ways, according to what was the period of development, in which the vegetative and reproductive organs were suffering drought. Either the number of spike-bearing stems per shrub is diminished, or the number of barren and underdeveloped florets per spike is increased, or again the absolute weight of the grain goes down.

From the table it may be seen that throughout the vegetation period there are two minima and two maxima in the resistance of spring wheat to drought. The first minimum falls into the period of leaf formation, the second, which is more pronounced, into the period of sexual cell formation. The first maximum is more sharply expressed than the second; it lies within the period of spikelet formation which in the late variety includes that part of the process of formation of leaves, when the growing cone of the stem is lengthening. The second maximum is not definitely established; it seems to fall into the phase of grain ripening.

Essential is the fact that the varieties tested showed by far smaller differences in their resistance to drought at equal periods of formation of vegetative and reproductive organs, than did the individual plants of the same variety when subjected to drought at different periods of development. This bears out the truth of the statement that a comparative study of the drought resistance of wheats should not be made without reference to the periods of development here described.

We deem it wise to point out in conclusion that so far as the transitional stages of plant development can be fixed across the periods in the formation of reproductive organs, it appears very interesting to investigate the intensity and trend of various physiological and biochemical processes in different wheat varieties subjected to soil drought during those periods.

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AGROPHYSIOLOGY

AMOUNTS OF ICE IN FROZEN WINTER PLANTS

By T. S. SULAKADZE

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According to the modern theory of plant's freezing, the death of the cells due to frost is considered as a result of the dehydrating and disruptive action of ice ([3,7]). As the decisive factor in this interpretation is the amount of ice formed outside the cells, the water retaining power of the plants is credited to be the basis of their frost resistance ([1,2,4,5,6,8,9]).

However, our knowledge about the amount of ice available in plants at low temperatures is very meagre. Considerable interest is due therefore to the estimation of the amount of ice forming in hardened as well as unhardened winter plants. Ice was estimated after calorimetric method in entire young winter plants and in their expressed juice. The results are summarized in Table 1.

Table 1

Amount of Ice in Winter Wheat Plants (in % of total water)

Varieties	−7°	−10°	−11°	−12°	−13°	−14°	−15°	−16°	−16.5°	−17°	−18°	−19°
Svea:												
23.IX	—	78	—	—	77	—	90	—	—	—	—	—
5.X	63	—	—	71	—	—	—	73	—	—	78	—
20.X	—	—	67	—	—	78	—	—	79	—	—	84
14.XI	—	—	—	58	62	64	65	—	—	67	—	70
4.XII	—	—	—	—	—	—	62	64	—	66	—	69
0760:												
23.IX	—	79	—	—	86	—	91	—	—	—	—	—
5.X	61	—	—	60	—	—	—	69	—	—	75	—
20.X	—	—	65	66	—	74	—	—	83	—	—	85
14.XI	—	—	—	—	61	61	63	—	—	64	—	69
4.XII	—	—	—	61	—	—	63	64	—	65	—	68

It may be seen from these data that the effect of hardening is to reduce the amount of ice in the plants. As on freezing of pure sugar solutions, so on freezing of plants the bulk of the water turns into ice at −7—10°C. and with further decrease of temperature the amount of ice goes up very slowly.

The percentage of plants survived after freezing to the temperatures, at which the amount of ice was estimated, is given in Table 2.

Table 2

Percentage of Survived Plants

Varieties	−7°	−10°	−11°	−12°	−13°	−14°	−15°	−16°	−16.5°	−17°	−18°	−19°
Svea:												
23.IX	—	0	—	—	0	—	0	—	—	—	—	—
5.X	100	—	—	35	—	—	—	—	0	—	0	—
20.X	—	—	30	45	—	46	—	—	0	—	—	0
14.XI	—	—	—	—	—	—	—	—	—	—	—	—
4.XII	—	—	—	100	—	—	65	—	—	17	—	3
0760:												
23.IX	—	0	—	—	0	0	—	—	—	—	—	—
5.X	100	—	—	50	—	—	—	6	—	—	0	—
20.X	—	—	37	38	—	71	—	—	20	—	—	0
14.XI	—	—	—	—	—	—	—	—	—	—	—	—
4.XII	—	—	—	100	—	—	70	—	—	20	—	3

A comparison of Tables 1 and 2 shows that the dying away of unhardened plants takes place when 78—79% of ice have been formed in them. But the same ratios of ice are not so injurious for the plants in the hardened condition. Hence the amount of ice is not the only factor in the death of the cells on freezing. Meyer (6) has found that the increase in bound water plays no essential rôle in the frost resistance of pine leaves. He believes the responsible cause to lie in some undiscovered physico-chemical properties of the protoplasm. The supposition put forward by Tumanov is that the stability of the protoplasm, along with other factors, is determining the resistance of plants to low temperatures. The superficial layer of the protoplasm appears to be able of changing under external conditions in such a way as to increase the resistance of the protoplasm to mechanical pressure. Preliminary experiments on the determination of the resistance which hardened and unhardened cells of winter wheat can offer to the mechanical pressure, have shown the former to be more resistant. The resistance was estimated in terms of the ratio of expressed juice (Table 3).

Table 3

Ratio of Juice Expressed from Hardened Plants of Winter Wheat (in % of total water)

Days of expression	Variety Svea	Variety 0760
11.X	28	28
21.X	26	28
1.XI	24	26
13.XI	23	25
21.XI	18	18
1.XII	18	18
9.XII	18	17

Periodical determinations of the water content in plants have shown it to be slightly variable; from September 29 till December 3 the changes in the content of water were fluctuating between 3—5%. With the progress of plants in hardening the amount of dry matter increased from 5.5% and 6.5% (October) to 7.5% and 9.5% (December) in Svea and 0760 respectively.

The juice expressed from hardened plants was tested for its protective action upon the cells of the red cabbage and beet and was found to be inferior in that respect to an osmotically equal sugar solution.

The data on the freezing of the juice expressed from unequally hardened winter wheat plants are referred to in Table 4.

Table 4

Amount of Ice in Juice Expressed from Winter Wheat Plants (in % of total water)

	Variety Svea					Variety 0760				
	−11°	−14°	−16°	−18°	−20°	−11°	−14°	−16°	−18°	−20°
20.X	—	78	83	88	89	—	76	81	84	87
17.XI	76	78	80	82	—	71	77	79	81	—
8.XII	74	77	78	79	—	72	75	78	79	—

In the entire plant samples freezing runs differently from as it does in the expressed juice. The amount of ice is lower in the former at a respective temperature. The amount of not easily freezable water goes up with greater celerity in the entire plants than in their juice as the hardiness rises. It would seem there are other causes, besides the degree of osmotic properties of the cell, which are determining the amount of unfrozen water.

The process of hardening tells also upon the response of plants to rapid thawing. The hardened plants, frozen at −10°C, remained alive after their quick thawing in a calorimeter, while the weakly hardened ones perished under the same conditions.

Conclusions

Calorimetric estimation shows that the effect of hardening is to reduce the amount of ice which is forming in winter wheat plants on their freezing. The conclusion to be drawn from comparing the amounts of ice formed in plants with the killing temperatures is that no complete correlation exists between these values, and one may suppose therefore that another effect of hardening is to increase the resistance of cells to the mechanical pressure of the ice.

This supposition is substantiated by the tests of hardened and unhardened winter wheat cells for their resistance to the mechanical action of a hydraulic press. The osmotic pressure is not the only factor which determines the amount of ice in the plants, as it will be obvious from a comparison of ice quantities in the entire plants and in the expressed juice.

The protective action of the expressed juice is weaker than that of the osmotically equal pure sugar solution. This is probably because substances with feeble protective power are present in the juice.

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PLANT PHYSIOLOGY

ON THE PHASES OF FORMATION OF GENERATIVE ORGANS IN WHEAT

By G. V. ZABLUDA

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Comparative studies on drought resistance in wheat at different phases (tillering, stalk formation, earing) suffer of a material defect, in the sense that at the phase of tillering nothing can be learned of the process of formation of generative organs, while the other two phases give only a rough idea of it. However, the knowledge of the condition of the developing generative organs is of decisive importance for estimating relative drought resistance in different varieties of wheat.

Kolomiez (1), Udolskaja (2) and Petinov (3) have pointed to the correlation of drought resistance with phases of formation of generative organs in wheat. Our investigations (4) have demonstrated in more detail the direction of the course of formation of generative organs as connected with the periods of the action of drought. Our subsequent works were intended to find special periods of the plant's life, the phases of formation of generative organs, and to establish specific reactions of the plants to soil drought and other conditions of plant's growth and development at these periods.

Observations were conducted on winter and summer early and late maturing wheat grown in pots under field conditions. Morphological differentiations in the growing cone and, later on, in the spikelets, flowers and sex-cells, were examined every day with the aid of a microscope and a binocular, beginning by young seedlings and up to flowering individuals. In contrast to the works of Percival (5), Veideman (6), Udolskaja (2) and Shestakov and Smirnov(7) stages of development of the plants were strictly considered during our studies of the process of formation of the generative organs. We were guided in these questions by the indications of Lyssenko (8); the works by Krajevoj and Kirichenko(9) and by Sapehin(10) were also considered. We attempted first to establish morphological characters which could serve to determine precisely the transition point from the preceding stage to the next one. It was necessary, further, to demonstrate within one and the same stage the existence of special phases of formation of generative organs. Naturally, one could not fail to pay attention to the period when formation of the generative organs has not yet begun, and when only formation and growth of the leaves as well as longitudinal growth of the growing cone of the stem take place.

On the basis of observations and parallel study of the influence of the soil drought, mineral and air nutrition, duration of the daylight or electric light,

we find it necessary to consider the following phases of formation of vegetative and generative organs, while conducting comparative physiological investigations on drought resistance in wheat.

1. Phase of Leaf Formation. The beginning of the phase coincides with the germination of seeds; its end—with the appearance of the primary spikelet protuberances on the growing cone of the stem. The appearance of the spikelet protuberances, under the conditions of the normal spring and summer day, handicaps the formation of new leaves and marks the end of the yarovization stage and the beginning of the light stage. However, under conditions of short day, new leaves may also appear after the formation of primary spikelet protuberances. In this phase tillering begins

Phases of ear formation in wheat. Figs. 1, 2, 3 and 4 — early summer wheat *Lutescens* 062. Figs. 5, 6, 7, 8 and 9 — late summer wheat *Milturum* 0321. Fig. 6a—winter wheat (Drawing by F. S. Elagin).

in summer wheat. The condition of the growing cone of the stem in this phase is presented in Figs. 1 and 5; Figs. 2 and 7 show it at the end of the same phase. It is of interest to note that appearance of primary spikelet protuberances takes place in the early maturing summer wheat *Lutescens* 062 along with the longitudinal stretching of the growing cone (Fig. 2), whereas in the winter wheat the growing cone stretches at the beginning (Fig. 6a) and later primary spikelet protuberances simultaneously appear along its whole length. The late maturing summer wheat *Milturum* 0321 assumes an intermediate position in this respect, i. e. the growing cone stretches to such an extent that 6—7 spikelet protuberances simultaneously appear laterally on it, whereas the remaining ones appear along with the further stretching of the growing cone.

2. Phase of Formation of Spikelets. The beginning of the phase—appearance of the primary spikelet protuberances on the growing cone; the end of the phase—appearance of conical outgrowths (pri-

mordia of anthers) on the primary protuberances, as well as of crescent-like half-rings (primordia of the flower- and spikelet-glumae). The light stage ensues in this phase, although it is not yet completed. Tillering continues as well as the growth of the leaves; the stem gradually begins to stretch. The condition of the primordium of the ear at the beginning of this phase is shown in Figs. 2 and 7; that at the end of this phase—in Figs. 3 and 8. The growing cone with primary spikelet protuberances formed on it is generally termed primordial ear. Following Prianishnikov and Jakushkin ([11]), the primordial ears in winter cereals appear in the autumn; according to our observations, they appear only in the spring in winter rye and wheat.

3. Phase of Formation of Flowers. The beginning of the phase—occurrence on the primary spikelet protuberances of conic outgrowths (primordia of anthers) and of the surrounding crescent-shaped half-rings (primordia of spikelet- and flower-glumae); the end of the phase—appearance of pollen grains in the anthers. During this phase the light stage ends and the sexual stage begins; occurrence of pollen grains in the anthers serve as an indication. Beginning with this moment, shortening of the duration of the day does not detain earing. The external appearance of the ear at the beginning of the stage is shown in Figs. 3 and 8, that at the end of the phase—in Figs. 4 and 9. The growth of the stem and leaves continues, and tillering ends toward the beginning of the middle of this phase, under the normal conditions of field and greenhouse experiments.

4. Phase of Formation of the Sexual Cells. The beginning of the phase—occurrence of pollen grains in the anthers; the end of the phase—blooming of the plants. During this phase the sexual stage of development is passed. The normal course of this stage may be traced by formation of fertile pollen, which is stained black in the solution of iodine in potassium iodide, and immediately bursts and discharges its contents when immersed in the decimolar solution of saccharose. When conditions necessary for the normal course of the sexual stage are lacking, pollen becomes sterile and stains in iodine solution yellowish-brown, and does not burst even in distilled water. Absence of light after the beginning of the sexual stage does not prevent earing. During the stage of formation of the sexual cells the most intense growth of the stem and the ear as a whole takes place. The external appearance of the ear at the beginning of the phase is shown in Figs. 4 and 9; at the end of the phase the ears have an appearance typical of the given variety of wheat during flowering.

The duration of the phases described above largely depends on the conditions of the stage development of the plants, mainly, on light and temperature. By changing conditions of the stage development one may be able to accelerate or to detain the tempo of the passing of each phase, and, in connexion with this, the numbers of leaves, spikelets and normally developed flowers change in the experimental plants. Against the background of the normal dosage of the nutritive mixture of Hellriegel plus optimal moisture, but at various temperature intensities and durations of the day illumination, in *Lutescens* 062 the number of leaves on the main stem changes from 6 to 9, the number of spikelets per ear from 7 to 18, and the number of normally developed flowers in the middle part of the ear from 2 to 5.

In connexion with the moisture of the soil and abundance of the nutritive materials consumed by the plant at different phases of formation of vegetative and generative organs, changes also occur in the number of leaves per stem, in the number of ear-bearing stems per plant, number of spikelets per ear, number of normally developed flowers per spikelet, and the quantity and the quality of grain, i. e., to use Sabinin's expression ([12]), the structure of the yield is changed. This was noted by Trubezkova ([13])

and Stankov ([14]). Therefore, it is necessary to consider the described above phases which pass in different varieties of wheat at different moments, not only in comparative studies on the drought resistance of plants, but also in other physiological, agrochemical and agrotechnical studies. This is the more important that the course of formation of generative organs reflects also the course of the stage development of the plants.

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PHYSIOLOGIE VÉGÉTALE

NIVEAU DES YEUX SUR LE SARMENT DE VIGNE, SUJET OU GREFFON, COMME FACTEUR DÉTERMINANT LA PROPORTION DE REPRISES

(SOUS L'ASPECT DE LA THÉORIE DES STADES DANS LE DÉVELOPPEMENT DES PLANTES)

Par P. G. TAVADZÉ

(Présenté par A. A. Richter, de l'Académie, le 20. III. 1939)

Le pourcentage de reprises parmi les plantes unies par soudure est une question de grande importance théorique et pratique, surtout dans le domaine de la viticulture où le manque de matériel porte-greffe est si accentué.

Un nombre de différentes données a été publié portant sur le greffage des vignes. La greffe réussit, par exemple, si le sujet et le greffon appartiennent à une même espèce (1). D'autres facteurs en jeu sont la maturité des parties à greffer, la direction dans laquelle est effectuée la section d'assemblage, la polarité et la dorsiventralité des boutures (2), le temps, quand le sujet et le greffon ont été pris (3), les conditions de leur garde pendant l'hiver et jusqu'au commencement de la greffe, les hormones de croissance, qui influent sur la formation des calus (4), etc.

Quant à l'influence que l'ordre des yeux sujets et greffons, c'est-à-dire leur distance à partir de la base du sarment, exerce sur la proportion de reprises, elle n'était pas, au moins en tant que je le sais, étudiée spécialement.

Pourtant les données expérimentales indiquent que les yeux d'un même sarment ne sont pas également fructifères, mais ils varient dans cette qualité en s'éloignant de la base. Les yeux de bonne valeur au point de vue de la fructification sont situés vers le milieu (chez quelques cépages dans la partie apicale) (5,6).

Dans les vignobles la greffe est effectuée ordinairement sur les sarments de vigne américaine, dont la longueur atteint souvent 8—10 m. Les sarments sont coupés en morceaux de 30—35 cm à partir du talon jusqu'à l'extrémité, et en titre de sujets on emploie les morceaux dont le diamètre n'est pas moins de 5—6 mm; tandis que les portions apicales minces, 50—100 cm de longueur, sont rejetées comme ne donnant pas de bons résultats. En qualité de greffons on se serve de sarment de vigne européenne, un mètre de longueur environ (après le pincement) et contenant 9—12 yeux. On les coupe de manière à avoir un oeil par morceau.

Il va sans dire que le développement et la croissance des sarments de vigne américaine et européenne ne se réalisent pas tout d'un coup, mais ils avancent graduellement pendant plusieurs mois, à travers différentes saisons (à partir

du printemps jusqu'à la fin de l'automne) et dans des conditions climatiques variables.

C'est pourquoi les différentes portions d'un même sarment, sujet ou greffon, ne sont pas égales au point de vue de leur valeur biologique et doivent varier aussi dans leur disposition de former le tissu de soudure.

Donc, en me basant sur la théorie des stades développée par Lyssenko et considérant que «le tissu d'une même tige peut contenir des portions non également avancées dans leur développement» (7), j'ai arrivé à la supposition que cette circonstance ne manque pas de produire un effet sur le rendement des greffes.

Pour vérifier cette supposition j'ai analysé, en 1936, l'activité de la catalase le long des sarments. Les résultats de ces analyses, portant sur la vigne américaine, sont présentés dans le tableau 1. On y voit bien que l'activité de la catalase va en croissant au fur et à mesure que l'on s'éloigne du talon.

Tableau 1

Activité de la Catalase (en ml d'oxygène dégagés au cours de 5 min.)

	Base	Milieu	Partie sous-apicale	Partie apicale
3309 Rip. × Berland.	12.2	18.6	20.4	19.7
420A	8.7	11.3	14.4	—

Ensuite j'ai passé à des expériences avec les greffes (faute de place ce ne sont que les résultats obtenus pendant une année dans la série principale des essais qui sont rapportés ici).

Les expériences portaient sur les sarments de la vigne américaine (Riparia × Berlandieri 420 A) ayant à peu près une même longueur *, de 8 m environ, coupés en morceaux de 30—35 cm à partir de la base jusqu'au sommet (bien entendu, on rejetait les extrémités non-lignifiées).

Étant coupés, les sujets américains ont été divisés en groupes suivants: I—première et seconde pièces à partir de la base (№ 1 et 2); II—cinquième et sixième pièces (№ 5 et 6); III—№ 8 et 9; IV—les pièces minces de la partie apicale (№ 10, 11, 12). Les pièces intermédiaires № 3, 4, 7 n'ont pas subi l'expérience. Chaque groupe après être mêlé soigneusement fut divisé en trois parties égales (chaque partie se composait de 100 pièces-sujets).

Le matériel greffon (variété Rkaziteli) fut distribué en trois parties: inférieures, supérieures et apicales. La partie inférieure comprenait les premiers trois yeux à partir de la base; la partie supérieure—deux yeux du milieu, la partie apicale—deux yeux extrêmes.

La greffe a été réalisée de la manière suivante: sur les premières 100 pièces-sujets (№ 1 et 2) du groupe I on greffait les yeux inférieurs; sur les secondes 100 pièces du même groupe (№ 1 et 2)—les yeux du milieu, et sur les 100 pièces restantes (№ 1 et 2)—les yeux apicaux de la variété Rkaziteli.

* La croissance et le développement sont certainement des notions différentes et une plante croissant rapidement peut être en retard dans son développement (Lyssenko); néanmoins, prenant les sarments d'une longueur égale et sur la même place, il était fort probable qu'il fussent homogènes au point de vue de leur développement par stades.

On procédait analogiquement en greffant les yeux inférieurs, du milieu et apicaux sur les sujets des groupes II, III et IV.

Les résultats des essais, présentés dans le tableau 2, ont mis en évidence que les sujets étant homogènes, le pourcentage de très bonnes reprises accroît à mesure que la hauteur des yeux sur le sarment greffon augmente.

Une seule exception fait le groupe I où le rapport est inverse. Ce fait tient à ce que les pièces inférieures du sujet ayant un diamètre trop grand, il était bien difficile de trouver un greffon de calibre identique, surtout parmi les yeux apicaux, et c'est pourquoi la soudure se réalisait defectueusement.

Tableau 2

Groupes-sujets	Ordre des pièces-sujets à partir de la base du sarment	Nombre de greffes	Niveau des yeux du greffon	Pourcentage de très bonnes reprises
I	1—2	100	Inférieur	12.7
	1—2	100	Du milieu	10.0
	1—2	100	Supérieur	4.0
				Total 26.7
II	5—6	100	Inférieur	6.6
	5—6	100	Du milieu	7.1
	5—6	100	Supérieur	18.2
				Total 31.9
III	8—9	100	Inférieur	12.7
	8—9	100	Du milieu	29.3
	8—9	100	Supérieur	21.7
				Total 63.7
IV	10—11—12	100	Inférieur	15.0
	10—11—12	100	Du milieu	21.0
	10—11—12	100	Supérieur	22.6
				Total 58.6

Le rapport entre la proportion de reprises et le niveau des yeux sur le sarment est encore plus évident dans la conduite des sujets (vigne américaine). Avec tous les quatre groupes de sujets nous avons employé de même greffons: les yeux inférieurs, du milieu et apicaux de la variété Rkaziteli. Alors dans ces greffes ce ne sont que les pièces-sujets qui varient suivant leur position le long du sarment. Et on voit dans ce cas-là que la proportion de reprises augmente rapidement et d'autant plus que l'on s'éloigne davantage de la base du sarment-sujet.

Par exemple, le pourcentage de reprises parmi les sujets № 1 et 2 (groupe I) fait, en total, 26.7; chez les sujets № 5 et 6 (groupe II)—31.9; chez les sujets № 8 et 9 (groupe III)—63.7.

Mais l'intérêt particulier de cette expérience réside dans le fait que les pièces-sujets apicales (№ 10, 11 et 12), les plus minces, qui sont ordinairement rejetées comme inutilisables pour la greffe, forment bien la soudure et donnent un assez bon pourcentage de reprises (58.6).

Les données de ces essais effectués au laboratoire nous mettent en mesure d'en retirer les conclusions suivantes.

1. Toutes les parties d'un sarment de vigne américaine (Riparia × Berlandieri 420A) ou européenne ne sont pas également capables de former la soudure. Leur valeur varie avec la distance des yeux à partir du talon.

2. Les parties du milieu et apicales dans la vigne américaine, et surtout dans la vigne européenne, étant plus jeunes et plus avancées au point de vue du développement par stades, donnent un grand pourcentage de reprises.

3. Dans la vigne américaine (Rip. × Berl. 420A) les parties minces lignifiées apicales des sarments forment la soudure mieux que les parties de la base, et le fait qu'elles ne sont pas utilisées pour la greffe est privé de fondement.

Pour résoudre la question définitivement, il est nécessaire de poursuivre les expériences à la propriété et d'étudier le développement des racines obtenues.

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PLANT ANATOMY

MORPHOLOGY OF THE OVARY AND OF THE IMMATURE FRUIT IN WHEAT

By V. G. ALEXANDROV and O. G. ALEXANDROVA

(Communicated by A. A. Richter, Member of the Academy, 17. III. 1939)

While embryogenesis beginning with the archesporium stage up to the embryo has been rather well studied in wheat ([1], [2]), transformation of the wall of the ovary into pericarp has not yet been sufficiently studied; it is especially true of the early stages of the fruit development at the period immediately before and following fertilization. This period is of prime importance for the later life history not only of the seed and embryo, but of all other parts of the fruit, too. The only work referred to in connexion with the inner morphology of the ovary of grasses in general is that by Schuster ([3]), whereas no studies on special morphology of the ovary and of the immature fruit are known to us. We have conducted the present study, the results of which are reported here, in order to fill up that gap, partly at least.

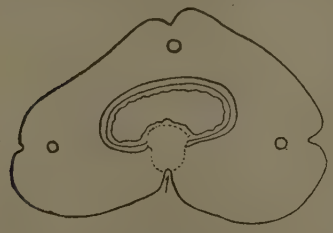

Fig. 1.

Let us consider first the question as to the number of carpels forming the pistil. Following Schuster, grasses in general possess tricarpellate pistils. However, as we have learned it from own experience, it is rather difficult to note signs of three carpels taking part in the formation of the ovary of wheat under ordinary conditions of cultivation of this crop. In 1938 one of us has collected ears of the variety *Lutescens* 062 on the territory of the Caucasian National Park, at the Abago pasture, near Guzeripl, altitude 1800 m above the sea level, where the Administration had organized a meteorological station and experimental cultures nearby. Wheat was sown only in June and, therefore, when the material was collected, September 14, ears were still green, and the achenes reached only early stage of maturity, viz. the beginning of milk ripeness and even earlier stages. Such abnormal conditions of development as well as its general impediment have evidently influenced the morphology of immature fruits which were clearly triangular, and, besides, each of their ribs bore a well expressed furrow. Fig. 1 represents a diagram of a cross-section through the middle of such a young fruit, showing first signs of endosperm formation, when differentiation of conducting system of the furrow just begins. Signs of tricarpellarity are, to our opinion, rather clearly expressed in this figure. The participation of three carpels in the formation of the ovary is first displayed in the presence of three well

developed bundles. Soon after fertilization these bundles obliterate and then dissolve.

Fig. 2 represents cross-sections through such bundles from the ovary of the variety «Severnaja skorospelka» (var. *ferrugineum sibiricum*; *a*—the bundle of the dorsal side, *b* and *c*—the lateral ones). These bundles are of a very uniform structure; there is no clear differentiation into phloem and xylem in them, and in this respect they resemble the terminal ramifications of the leaf nerves. Like in a leaf, the nerves of the ovary wall consist of a small number of identical vessel-elements surrounded by closely adjoining parenchyma cells which form the sheath of the nerves.

Fig. 3 represents a diagram of a longitudinal frontal section through the ovary of wheat from Afghanistan (var. *Erythrospermum speltiforme*). The nerve of the dorsal side terminates blindly, the lateral ones enter the ramifications of the stigma. The path of the lateral veins is represented in the figure. It is of interest that as long as the veins pass through the ovary wall, their conducting elements are not lignified; however, as soon as a vein enters the region of the stigma, some of the conducting elements assume spiral (evidently lignified) thickenings, that are thracheids with spiral thickenings. In the ovary the conducting elements have obscure thickenings and structurally remind segments of the primary sieve-tubes*. Such a sharp difference between the morphology of the conducting elements of the ovary and those of the stigma undoubtedly demonstrates a definite physiological difference between these two components of the pistil. The veins of the ovary serve to fill up cells of the latter with nutritive and plastic materials which are transported further to the developing seed. No nutritive or plastic substances are deposited in the cells of the tissues of the stigma; this is true at least for such materials as starch and proteins. Structural changes of the anatomical elements of the conducting system at its transition from the ovary to the stigma is very peculiar, although the two portions of the system represent continuation of one another. This phenomenon shows how intimately are co-ordinated with one another structural peculiarities of the various parts of a given organ with those of its physiology.

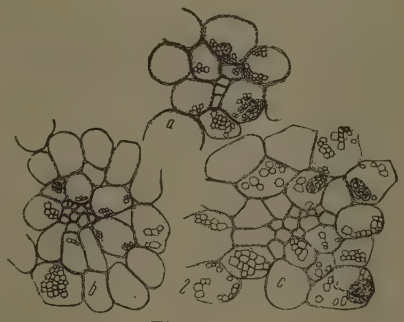

Fig. 2.

The ovule of the grasses, in particular that of wheat, gradually changes from an atropic to an anatropic one at the period of formation of the embryo sack in it ([4,5]). The process of turning of the ovule is also followed by a movement of the placental-chalazal region possessing an exclusively short funiculus from the inferior position into a lateral one (with regard to the general orientation of the ovary wall) (Fig. 4, diagram of the longitudinal saggital section through the ovary). As soon as fertilization has taken place, the whole prospective achene begins energetic growth so that it stretches 3—4 times within a short time. This period of intense longitudinal growth of the young achene may be termed the great growth period. Longitudinal growth is effected mainly by stretching of the placental-chalazal region which is trans-

* After treatment of sections with Cl-Zn-I only veins are stained light-blue, whereas the rest of cells of the ovarian tissues remain yellow: the cell walls of the parenchymatic elements, the pectinous ones, those of the hairs, the lignified ones.

formed into the furrow of the kernel ([6]). At the growth of the young fruit, when it passes under the stimulating influence of fertilization from the ovarian condition to that of the prospective fruit, the veins of the ovary are strongly stretched; immediately following this, begins the process of their obliteration and final dissolution with the only exception of the very lowest regions which continue functioning for some time; at any event obliteration is never delayed. It is well known that the stigmata of grasses wither and dry up very soon after fertilization. At the same time, i. e. immediately following fertilization, begins differentiation of the conducting system of the furrow; this system replaces the veins of the ovary and has other functions, viz., to transport plastic and nutritive materials into the developing seed. It is possible that just in connexion with the peculiarities of the functions of the conducting tissue of the furrow the structure of its anatomical elements is different from that of the ovary. The conducting tissue of the furrow consists of elements which correspond to xylem and phloem of the normal collateral bundles, at least at the lower part of the furrow of a young achene ([7]). The conducting system of the furrow of a grass is functionally analogous to the conducting system of the funiculus and especially to that of the hylum of such

Fig. 3.

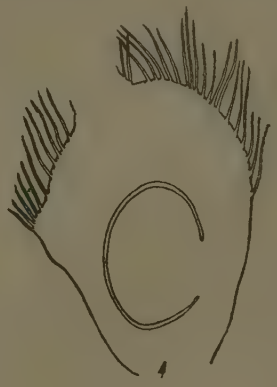

Fig. 4.

plants as, for example, are the leguminous plants ([8],[9]). The very structure of the xylem elements of the conducting tissue of the furrow strongly reminds the structure of the tracheids of the so-called tracheid-island of the hylum.

In the ovary of wheat there exist thus prior to fertilization three structurally similar veins, in conformity with the tricarpellate nature of the pistil. These veins represent the special conducting system of the ovary, and two of them continue into the stigmata. Following movement of the ovule from the atropic position into the anatropic one and after the embryo sack is formed at this period, fertilization stimulates strong and rapid longitudinal growth of the young fruit, which is largely effected by growth of the zone which includes the placental-chalazal region. Longitudinal growth of the fruit causes strong stretching of the ovarian veins which is followed by a rapid obliteration of the veins and then by their dissolution. Instead of the disappearing conducting system of the ovary, fertilization stimulates formation of the conducting system of the furrow; the latter includes the placental-chalazal region of the young fruit. The conducting system of the furrow is, therefore, a special conducting system which transports nutritive and plastic materials to the

developing endosperm and embryo. In its functions and structural peculiarities of the xylem elements the conducting system of the furrow may be compared with the conducting elements of the funiculus or of the hylum of plants like leguminosal.

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PLANT ANATOMY

ANATOMICAL CHARACTERS OF THE ACHENES OF THE EARLY MATURING AND LATE MATURING WHEAT

By V. G. ALEXANDROV and O. G. ALEXANDROVA

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The duration of the growth period is a most important property which characterizes a given variety of wheat. It is quite natural, therefore, that students pay great attention to phenomena of early and late maturation. Upon closer examination of these phenomena the high complexity of factors composing them becomes apparent, as well as their variability and strong dependence on surrounding medium and climatic conditions. Early maturing varieties, for instance, which originate from northern localities, should strongly differ in certain biological features from those of southern origin. The time of earing is of great importance. Late maturing forms of wheat are represented by early and late earing types, the two differing biologically to a no lesser degree than do the late and early maturing varieties. The practical importance of earliness is very great: this property determines to a considerable extent the possibility of introduction wheat further north.

While studying the anatomical structure of achenes of early and late forms of wheat at various stages of development, we succeeded in finding a series of structural changes which were sufficiently typical and correlated with the degree of earliness. Such changes are most clearly expressed in the pericarp of the achene. The present paper is intended to give a short description of these changes. The material which served for the present investigation was collected in the summer 1938 in the fields of the All-Union Institute of Plant Industry, Pushkin, Leningrad region, at various periods. Soft wheat, *Tr. vulgare* Host., was subjected to study.

In a mature achene of the highest types of cultivated wheats, both soft and hard, only vessels located in the furrow are left of the conducting system of the ovary wall; moreover, even these remnants are obliterated, the majority of elements being compressed or even dissolved. In a young achene the conducting system is considerably richer, especially at the early stages of endosperm formation.

Fig. 1 (above) represents a diagram of a cross-section through the middle of a very young achene of wheat, variety *Erythrospermum* 0341, at the stage of the beginning of endosperm formation. Aside from the conducting system already formed in the furrow (black regions), three additional vascular bundles may be distinguished in the wall of the young pericarp; two of them are located laterally, the third assuming dorsal position. Fig. 1 (below) represents cross-section through one of the lateral veins under somewhat higher magnification. The spinal vein, as shown long ago by Schuster (1)

in barley, ends blindly at the top of the achene, while the lateral ones are continued into the stigmata. In the basal portion of the young achene all the veins merge into a common knot of the conducting system of the very short pedicel which is attached to the axis of the spikelet. The veins of the wall of the pericarp are most expressed at the period of flowering. From the moment of fertilization on begins the process of their obliteration. The vein of the spinal side obliterates first; in general, it is weaker developed than the lateral ones. Obliteration of the veins spreads downwards beginning with the upper portion of the achene. Obliteration of the pericarp veins is completed in shortest time in the achenes of early maturing forms of wheat. For example, whereas in northern early maturing forms (*Tr. vulgare* var. *ferrugineum sibiricum*, *erythrospermum ircutianum*, *milturum konotense*, *lutescens praecox*) the veins rapidly disappear almost without rest along the whole length of the young achene, in late maturing wheat (varieties Moskovskaja 2411, squareheads from Holland and Finland) the veins remain inobliterated during a comparatively long time in the lower portion of the achene, being much later visible on sections, even when they no longer have any function. The veins are distinguishable in late maturing forms after obliteration of the vascular elements up to the very beginning of endosperm formation (deposition of the chondriosomal starch); in early maturing forms the veins disappear immediately after fertilization during the longitudinal growth of the ovary containing the fertilized ovule, with the first signs of endosperm formation.

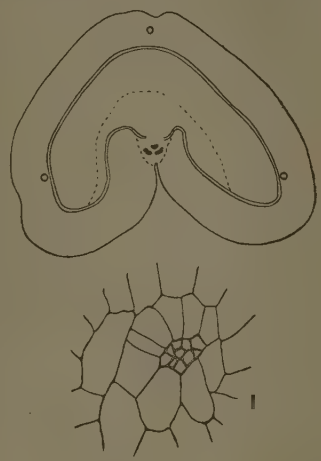

Fig. 1.

Vascular elements of the furrow appear only when the stage of endosperm formation arrives, when parenchyma cells composing the tissue of the ovary wall are rather rich in starch deposit. The veins which pierce the ovary wall at early stages of development of the wheat fruit represent, therefore, the conducting system which stimulates accumulation in the ovary of nutritive and plastic materials which are consumed for the initial phases of building up the seed. The conducting system of the furrow is formed instead of this system; it takes part in the final ripening of the achene.

Along with the ripening of the achene of wheat takes place not only emptying of the pericarp cells of the deposits accumulated in them, but dissolution of the very cell body, too. Out of 20 cell layers composing the pericarp layer of the young fruit, a total of no more than 4—5 layers remain toward the time of maturity. Moreover, such definite and clean-cut differences are observed in the condition of structure of the pericarp of mature achenes of early maturing and late maturing forms of soft wheat, that they make it possible to get some idea of the peculiarities of the physiology of ripening in the two ecological kinds of wheat.

Fig. 2, fragment *a* (left) represents a portion of pericarp from a cross-section of the lateral side of the middle of the achene (lower half) of the one of the northern early maturing varieties (var. *ferrugineum sibiricum*). The pericarp practically consists only of two layers, of the outer and inner epidermis; almost nothing is left of the mesocarp cells in this zone of the achene, almost everything is dissolved, the remnants being collapsed into a solid mass possessing a slightly expressed fibrillar structure. Cells of the

outer epidermis are also strongly obliterated, in some places up to complete compression of the cellular lumen. Fully preserved are only cells of the inner epidermis of the pericarp (cross-cells), which are supplied with slit-like pores which are close to each other. The pericarp of other northern early maturing forms is similarly built.

Fragment *b* of the Fig. 2 (right) represents an analogous portion of achene of a representative of the medium early variety ([2], [3], [5]), *Lutescens* 062. A great number of cell layers of the pericarp is preserved in this group of wheats till the moment of full maturity; moreover, very well expressed layers of hemi-cellulose are deposited in the cell cavities of the epi-mesocarp. Slit-like pores in the cross-cells are further apart from each other as compared to the northern early maturing forms. Emptying of the pericarp of deposits of nutritive and plastic materials takes place not so quickly. Variety *Erythrospermum* 0341 behaves similarly.

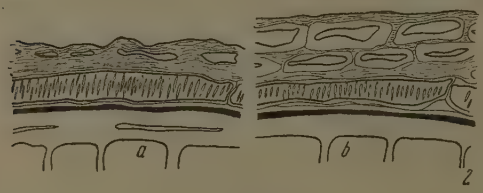

Fig. 2.

Northern early maturing forms which belong to the boreal ecological type represent low growing plants possessing relatively small leaves and ears. Varieties *Lutescens* 062 and *Erythrospermum* 0341 are representatives of the steppe-type. They are wholly normal wheats. Veins piercing the wall of the young pericarp are preserved in these forms somewhat longer as compared to the northern early maturing forms; similarly, ripening of the endosperm is completed later. In early maturing forms filling up of the endosperm cells with starch is arrested before reaching completion, owing to which fact the achenes of the northern early maturing forms are nearly always flinty, since protein layers separating grains of starch are rather thick. Walls of all the endosperm cells in early maturing forms are well expressed and easily distinguishable. Filling up of endosperm cells with chondriosomal starch proceeds markedly further in medium-early wheats which facilitates formation of the floury consistence of the endosperm tissue, especially in the awn-less forms (var. *Lutescens*). The walls of the endosperm cells are not so clearly expressed here, when sections of mature achenes are studied, and in central portions of the endosperm tissue the walls may be distinguished only with difficulty.

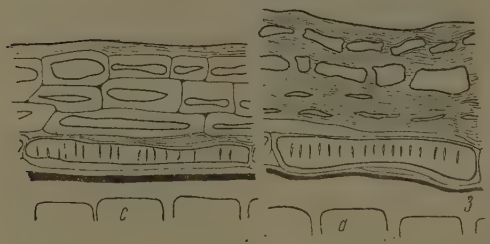

Fig. 3.

Fig. 3, fragment *c* (left) represents a portion of the pericarp of the lateral side of the lower half of an achene of the medium-early wheat, variety *Caesium* 0111. Although the number of pericarp layers at the moment of full maturity remains the same as in *Lutescens* 062, the character of the structure of the epi-mesocarp is somewhat different. The epi-mesocarp of wheat of the *Lutescens* 062 type is in the main composed of the products of obliteration of the mesocarp cells, composed of cellulose; in the cell cavities of the peripheral layers rather thick deposits of hemi-cellulose are formed. The deposits of hemi-cellulose are even thicker in the epi-mesocarp of the medium-early wheat, as may be seen from the fragment *c* (compare with fragment *b*). It is probable that, under the conditions of the 1938 summer at Pushkin, not only depo-

sition of hemi-cellulose in the cells of epi-mesocarp took place, but was also effected the transformation of the cellulose material of the walls of these cells into hemi-cellulose, accompanied by swelling of the cell walls. Therefore, cells of epi-mesocarp were so tightly pressed to each other and formed almost polyhedral structures, leaving layers of fibrillar hemi-cellulose only on the outer and inner surfaces of the epi-mesocarp. The cross-cells are markedly thickened in medium-early wheats as compared to the early-medium-early and early forms, the slit-like pores are much farther apart.

The ripening of the endosperm in medium-early wheats takes more time than in early-maturing ones, and intermediate stages of filling of cells are easier to find here. The cell walls in the central region of the endosperm tissue are so thin, that it is very difficult to distinguish them, and, moreover, only when cells are freed of their contents.

The achenes of the medium-early winter variety *Lutescens* 0329 have the same structure as in *Caesium* 0111.

Fragment *d* of the Fig. 3 (right) represents a portion of the pericarp of the late maturing winter variety Moskovskaja 2411. Five cell layers remained visible in the pericarp, two of them in the form of obliterated remnants. There are no deposits of hemi-cellulose. A structure of a similar type is peculiar to achenes of squareheads, with the only difference that deposits of hemi-cellulose are found more often here.

Starch remains in the pericarp cells during a very long time and, besides, fills up all the cells from the bottom to the top of the young achene. The cells of the endosperm are as strongly filled, especially with chondriosomal starch; only insignificant layers of protein are left, so that typical floury structure is often produced. Cell walls are distinguishalbe only on the periphery of the endosperm. Owing to this, the endosperm looks like a sack tightly filled up with various kinds of starch.

Achenes of wheats differing in the length of the growth period differ structurally in a sufficiently definite manner. These differences depend, on the one hand, on the degree of filling and on the rapidity of the evacuation of the deposits of the nutritive and plastic materials from the pericarp cells; on the other hand, they depend on the velocity, duration and degree of filling of the endosperm cells with reserve materials. The two sets of characteristics are consequences of physiological peculiarities of the given varieties of wheat. The pericarp in early maturing wheats is the thinnest, that in late-maturing wheats is thick.

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PHYTOPATHOLOGY

RESPONSE OF THE MYCELLIUM OF *USTILAGO TRITICI* IN WHEAT GRAIN TO ULTRA-VIOLET RAYS AS DEPENDENT UPON ITS CONDITION

By V. A. JABLOKOVA

(Communicated by A. A. Richter, Member of the Academy, 17. III. 1939)

The object of the present investigation was to find some criterion for judging about the living condition of smut mycellium in wheat grain on direct observation of the parasite in the tissue of the host plant. The search for such a criterion was dictated by the necessity to have a clue in developing new methods to control the disease, without having recourse to the growing of plants.

The attempts to use the method of vital staining with neutral red ended in failure. While a typical reaction (granule formation) for the cell norm was thereby obtained, it proved to be not a means for discerning the mycellium of the parasite from the tissue of the host in life time, for the tissue of seed embryo and the mycellium both responded equally to the treatment. We resorted therefore to another method, very sensitive and essentially different, the fluoromicroscopical analysis.

In the literature it had already been indicated (1) that the fluorescent effect induced by ultra-violet rays in the contents of the epidermic cells in the scale of onion *Allium cepa* is apt to vary, according to the condition of the cells at the time when they are being impregnated with fluorescent substances.

This indication suggested the application of the fluoromicroscopical method to the subject of our investigation. The procedure adopted by us was as follows. The seed of wheat varieties *Albosar*, *Lutescens* 062 and *Albidum* 721—one portion of which had been subjected to wet thermal treatment—was artificially infected with *Ustilago tritici* and kept in a thermostat at 26—28° for 1 — 6 days (in wet filter paper, in Petri dishes). Then longitudinal sections made through the centre of the seed embryo were put on to the object glass into a drop of freshly prepared 0.005% solution of eosin* with 0.1 *n* KNO_3. After being left for 3 min. in this condition, the sections were thoroughly washed with distilled water. Thus prepared, they were examined (first without cover glass) in ultra-violet light of a fluorescent microscope. The localization of the smut mycellium in the embryo of germinating seed was distinctly observable. The mycellium showed characteristic slightly sinuous outlines with typical swellings in the places, where it was traversing the intercellular spaces, and at the ends of the hyphae (Fig. 1); it formed broken threads or interlacements.

* Eosin yellow (Kahlbaum).

On examining the sections of wheat grain on the object glass in an unstained drop of water under ultra-violet light of the fluorescent microscope, one may see that no other tissues in the grain besides the aleuronic layer* and the scutellum of the embryo (which exhibit light blue fluorescence of their own) are emitting fluorescent light. Neither the endosperm nor the rest of the embryo did fluoresce. The same is true of the loose smut which has no proper fluorescence either.

However, in the sections impregnated with eosin a secondary fluorescence is observed to appear (2) in the embryo and endosperm. In that case the embryo fluoresces with no bright greenish-yellow, while the gluten protein of the endosperm emits yellow fluorescent light. But no fluorescence is to be seen in the starch grains of the endosperm. The scutellum of the embryo and the aleuronic layer did not change their fluorescent colour under the influence of the eosin, because they seem not to imbibe the latter.

Yet the mycellium of the smut having passed from the scutellum into the bud of the embryo fluoresces in an eosin treated section with a bright canary-yellow hue, as it did in the epithelial layer of the scutellum. On the other hand, the mycellium in the parenchyma of the scutellum and aleuronic cells emits blue fluorescent light. The difference in colour may, probably, be explained by the difficulties experienced by the eosin on its penetration into the tissue of the scutellum. Likewise there was no yellow fluorescence in the hyphae of the mycellium, whose cells had lost their protoplasm. The practical interest in our observations centered, however, chiefly about the mycellium which had penetrated the bud of the embryo.

We thus found the different parts of the grain and even of embryos with the fungus mycellium included in it to fluoresce differently, according to their chemical composition. The pictures obtained in that way are made up of the proper fluorescence and secondary fluorescence of the constituents of the grain and parasite.

Smut mycellium may be distinguished from the surrounding tissue of the host by its stronger fluorescence which has besides a different colour. The bright canary-yellow fluorescence of the fungus stands out against the background formed by the pale greenish-yellow fluorescence of the embryo bud.

The localization of the mycellium in the grain was the same whether or no the seedlings of the varieties tested, ranging in age between 1 and 6 days, had undergone wet thermal treatment.

On our material we have observed a total lack of mycellium in the embryo bud during the first days of germination, while it grew out there from the scutellum in the seedlings ranging between 3 and 7 days irrespective of their being heated or not (for 4 hours at 30°C and for 8 min. at 52°C**).

In some cases, however (on heating the seed at 53°C for 7 min. after its soaking at 30°C for 4 hours), it was observed in three day old seedlings that the single hyphae of the mycellium had made their way in the bud of the germinating embryo, but its cells were destitute of protoplasm. The latter was preserved only in the apical cells, by whose means the mycellium was spreading inside the tissue and which emitted mat yellow fluorescence.

* The walls of the aleuronic cells exhibit fluorescent light of brilliant light-blue colour; the contents of those cells emit pale grey-blue light. The seed coat has a light fluorescent hue.

** Standard method of wet thermal treatment of wheat grain for controlling smut.

And again, in other grains under the same condition no protoplasm at all was observed in the mycellium which had entered the embryo bud. But in all of the cases we invariably found the mycellium in the epithelial layer of the scutellum to fluoresce with mat yellow hue and to remain intact in its morphological specifity, which is characteristic of the hyphae in the scutellar epithelium and strongly differs from the hyphae in other parts of the embryo and grain in its being characterized by a full-formed and greater volume of the mycellium.

That the smut mycellium had not been killed by the treatment, is obvious from the fact that it was growing in the embryo bud of the heated seed on germination during a certain, albeit a short period of time. But its intensity of fluorescence was weaker than in the control.

When the action of the eosin is tested on the killed smut mycellium in the grain of one day wheat seedlings, heated at a higher* temperature (up to 55°C), one can observe a stronger extinction of the fluorescence in the protoplasm of the hyphae which lose moreover the purity of their colour. Among other fluorostains involved in the tests the erythrosin gave positive results which were, however, essentially similar to those obtained with the eosin.

On the basis of the experiment here reported we may bring a certain degree of precision in the foundation of the wet thermal treatment as a method of controlling the loose smut disease of wheat. The essential of this procedure lies in that the smut mycellium is injured in the grain rather than killed. Although the injury thus occasioned does not exclude at once the possibility for the mycellium to develop, when favourable conditions are available, with the tissues of germinating seed, but in its further development it lags far behind and finishes with dying. The fact that the smut fails to manifest its presence in the plants grown from the seed subjected to the treatment in question is the result of this rupture between the parasite and the host and the escape of the latter from the injury.

The significance of the fluoromicroscopical method lies not only in the possibility of discerning the fungus from the host tissue by the colour and intensity of the fluorescence emitted by the mycellium. The most essential and important in this procedure is the means to distinguish the living mycellium from the dead one amidst the tissues of the host plant.

With this method in use we are not confined therefore to the limited time of the vegetation period and the process of work is accelerated. Its decided advantage over other methods based upon vital observations is that the pictures obtained by its means are more contrasting, bright and distinct.

The importance of the further development of the fluoromicroscopic method is to be emphasized. It should be extensively used in the scientific work concerned with the protection of plants. In some cases it may prove to have no equal, especially when observations of the parasitic fungus in the living tissue of the host plant and its change due to injury or necrosis are to be made in life time.

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* As compared to the standard.

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DEVELOPMENT MECHANICS

RÔLE OF THE OLFACTORY SAC IN THE DEVELOPMENT OF THE CARTILAGE CAPSULE OF THE OLFACTORY ORGAN IN *URODELA*

By O. I. SCHMALHAUSEN

(Communicated by I. I. Schmalhausen, Member of the Academy, 19. II. 1939)

Morphogenetic correlations between parts of the embryo play an important rôle in the development. Yet, they are far from being sufficiently studied. Up to the present chief attention was paid to finding out the dependence in the development of ectodermal rudiments, whereas such relations as the formation of skull parts under the influence of epithelial rudiments of the sensory organs, have been studied comparatively very little. Somewhat more numerous are the studies devoted to the examination of the formation of the ear capsule as influenced by the membraneous labyrinth ([2], [3]).

In the present investigation the importance of the ectodermal olfactory sacs for the development of the rostral part of the skull was examined.

The cartilage capsulae of the olfactory organs in *Urodela* develop of the mesenchyma which surrounds the epithelial rudiments. It is quite natural to suppose the development of the capsule to be in some way influenced by the olfactory sac. Burr ([1]) removed one of the two olfactory sacs in embryos of *Amblystoma*. It was found that the capsular structures on the operated side of the head do not develop. Burr gives the following interpretation of the process of reduction: after removal of the sac, the whole mesenchyma located on its dorsal side migrates ventrally and joins the trabecular mesenchyma, increasing thereby the mass of the future trabecula. In Burr's opinion, the operation calls forth only a rearrangement of the mesenchyma which chondrifies at the lowest level. The experiments of this author prove a certain dependence of morphogenesis, while the conception as to the character of this dependence remains a matter for dispute.

New data concerning this question are stated below. Two problems were set for experimental research: 1) to define the formative tendencies of the skeletogeneous material which serves to build the capsule (experiments of removal of the right olfactory placode); 2) to directly demonstrate the formative influence of the olfactory sac by placing it in an environment of a foreign skeletogeneous material (grafting of an olfactory placode).

Extirpations were carried out on the newt *(Triton taeniatus)* and on the axolotl *(Amblystoma mexicanum)* at the stage of tail bud. The operated larvae developed during a period from one to three months.

In the absence of the olfactory sac the olfactory capsule is not formed. The roof and lateral wall of the capsule do not develop. The horn of the trabecula also fails to expand either in the dorsal direction to form the medial wall, or lateralwards, to form the bottom of the capsule. Without developing any outgrowths, the trabecular cartilage develops in a simplified form and becomes more massive than the medial wall of a normal capsule; on cross-sections it has the appearance of a triangle (Fig. 1). However, the graphic reconstruction of the rostral part of the head shows a significant reduction of the right trabecula as compared with the cartilage mass on the unoperated side of the head. Thus, my experiments do not confirm Burr's conclusions to the effect that, as a result of extirpation of the placode, the amount of cartilage in the region of the forebrain remains unchanged.

The removal of the placode indirectly tells on the development of the crest of the right trabecula, too. The smaller the right hemisphere of the brain which is always considerably reduced in the absence of the olfactory sac, the lower is the crista trabeculae.

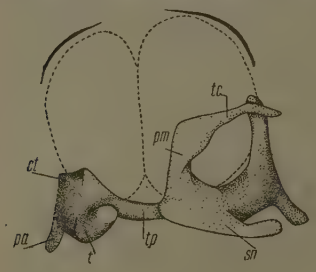

Fig. 1. Graphic reconstruction of rostral cartilages in *Triton taeniatus*. Anterior view. The right olfactory capsule is not formed owing to removal of the olfactory sac. The dotted line shows the cross-section through the brain behind the olfactory organs. Ossa frontalia are black. *pa*, antorbital process; *ct*, crista trabeculae; *pm*, medial wall of the capsule; *sn*, solum nasi; *t*, trabecula; *tp*, trabecular plate; *tc*, tectum nasi.

In those cases when on the sections were found if but small remnants of olfactory epithelium, its influence is at once noticeable on the cartilageneous structures. First of all appears the bottom part of the capsule. With larger portion of the olfactory epithelium, or in the presence of a rudimentary sac, develop the medial wall and the roof of the capsule. In these cases the trabecular cartilage and medial wall of the capsule are greatly thickened. The bottom of the capsule is slightly thickened; besides this, it is shortened in proportion to the size of the sac. Thus, with a reduced sac, the cartilage appears to be somewhat in excess, and without forming considerable outgrowths it seems more massive. The roof of the capsule usually corresponds most of all to a sac, both in size and shape.

Obviously, the presence of the olfactory sac in both species of *Urodela* used in this experiment is necessary for the proportional development and normal formation of the cartilage of the rostral part of the head.

Extirpations of the placode made it possible to study the behaviour of the skeletogeneous material in the absence of the olfactory sac. Yet, it remained obscure whether the ectodermal rudiment serves only as a passive substrate for the settling mesenchyma, or else whether it attracts and activates the adjoining tissue. To form a judgment on this matter, grafts of the conjectural inductor were made into a foreign environment, where there exists a local skeletogeneous mesenchyma.

When grafting the olfactory placode into the ear region of the head, an olfactory sac develops out of the graft, and around it cartilageneous laminae reminding the capsule roof. The mesenchyma located on the surface of the graft begins to chondrify in the medial part, while laterally it is united with the tissue of the olfactory sac near its orifice. This spot looks as if the wall of the sac became loosened here, cells creeping out of it which are disseminated over the surface of the sac and transformed into mesenchyma and then into cartilage. The same pictures may also be seen in the normal development of the roof and bottom of the capsule, on sections through the

nostril region of the olfactory organ. Besides the formation of such a kind of cartilage laminae, the grafted olfactory sac has a formative influence on the foreign skeletogeneous material, too. When grafting a placode into the ear region, the local cartilage forms protuberances which join the lateral lamina (i. e. the olfactory cartilage proper) complementing the capsule of the graft, the same as in normal development the trabecular outgrowths complement the olfactory capsule.

Comparing the results of extirpation and grafting, it may be safely said that the rôle of the olfactory sac in the development of the capsule is very great, and at the same time not identical in the development of various parts. Without a sac the dorso-lateral part of the capsule cannot form at all, and it seems to develop at the expense of the material originating out of the margin of the sac. The medio-basal part also develops under the influence of the sac, which calls forth outgrowths of the trabecular cartilage, and provides the mesenchyma for the lateral part of solum nasi at least.

The third series of experiments, in which the olfactory placode was grafted side-by-side with the identical rudiment of another embryo, gave similar result. In such grafts, the walls of the graft reach an almost normal histological differentiation. Nearly in all cases the olfactory sac is connected with the epidermis, forming a nostril; yet in no case did its subdivision into sections occur. The cartilage laminae on the graft have a clearly expressed character of dorso-lateral elements of the capsule. They are usually connected with the roof of a normal capsule, forming an excrescence of the capsule at the point of fusion. The graft does not divert the capsule material of the host; there is no appreciable decrease of the mass of cartilage around the olfactory sac of the host. On the contrary, the roof of the capsule is raised and thickened at the place of joining with the lateral cartilages, related to the graft (Fig. 2).

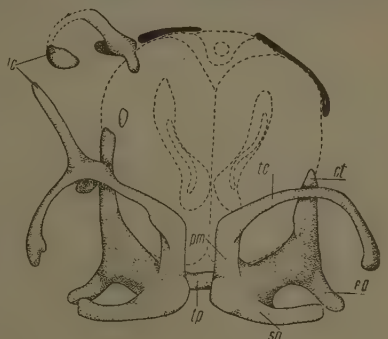

Fig. 2. Graphic reconstruction of rostral cartilages in *Triton taeniatus* (later stage, drawn to smaller scale than Fig. 1). Anterior view. Above the right olfactory capsule additional cartilage elements which have developed around the grafted olfactory sac, are present. *lc*, cartilage laminae of the graft.

In this series of experiments the crest of the right trabecula is considerably higher than on the control side of the head, in accordance with the greater height of the hypertrophied right half of the brain.

Conclusions

1. In the cartilage capsula of the olfactory organ two sections of different origin should be discerned: the medio-basal part formed by the horn of the trabecula, and the olfactory cartilages proper which originate later.

2. The importance of the ectodermal nasal rudiment for the formation of cartilage is quite manifest in all the experiments. Besides, another aspect of the dependence of cartilage elements is to be traced: tectum and partly solum nasi are apparently derivatives of the sac itself, and are formed out of the mesectoderm migrating from its nostril part, while the remaining capsule is formed at least under the influence of the sac, this being necessary for the cartilages of the trabecular part to reach their normal size.

3. Cristae trabeculae are correlated in their development with the forebrain. In the case of hypertrophy of one of the brain hemispheres, the crest of the nearest trabecula increases in height, whereas underdevelopment of the hemisphere results in its corresponding decrease.

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DEVELOPMENT MECHANICS

MORPHOGENETIC INTERACTION BETWEEN THE EYE RUDIMENT AND THE COVERING ECTODERM

By N. I. DRAGOMIROV

(Communicated by I. I. Schmalhausen, Member of the Academy, 19. II. 1939)

In the previous communication ([1]) it was shown that the contact with the lens-forming epithelium contributes to the differentiation of the eye. Further experiments made it possible to come to more precise conclusions, having clearly shown the simple mechanism of integration of this organ which is formed out of rudiments of different origin.

At present, we dispose of the following data concerning the induction of the retina by the ectoderm.

In the optic cup turned 180° about its dorso-ventral axis in the axolotl regularly occurs the formation of a second retina, as a result of the contact of the prospective epithelial pigment layer with the material of the lens. The same effect was obtained in *Hyla arborea* and *Rana arvalis* when operated at the stage of formed optic vesicles with thin medial wall, and in *Rana esculenta*—at the late neurula stage, when the eye rudiments still have the appearance of compact salients of the medullary tube. In this cases the primary retina is turned medially, its pupil is empty, or with closed edges; additional retina is in normal relations to the derivatives of the ectoderm.

The turn of the primary optic vesicle in the axolotl is always followed by regulation of the eye; a single retina develops with a lens in the pupil turned laterally.

In the experiment of rotation of the eye together with the lens-forming epithelium in *Pelobates fuscus* (operation stages from medullary tube to a flat tailed embryo with sac-like lenses), is rather often observed induction of the retina in the part of the optic cup adjacent to the ectoderm which has substituted the lens anlage. A few cases of this kind though lacking full distinctness were observed in the axolotl and *Triton taeniatus*.

Transplantation of the eye rudiment at the stage when its walls are already of unequal thickness, while the distal one has not yet begun to invaginate, under the skin of the head in *Pelobates*, also gave a positive result.

Lastly, in one case in an axolotl, fixed 48 hours after operation, the optic cup grafted at the 26 stage (in terms of Harrison's row) into the pronephros region developed a second retina which was closely pressed against the ectoderm.

In all were obtained 31 cases of obvious induction*; out of this number

* The description of the most typical specimens and photographs are given in a paper in press.

15 refer to the influence of the lens-forming area. A more or less normal development of the organ in correct orientation should be explained by its rotation after operation; but sometimes there occurs, no doubt, a perfect reconstruction of the early rudiment (100% regulations in experiments of the primary optic vesicle in the axolotl). A negative result is rather frequent in cases when the eye is separated from the epidermis by an interlayer of connective tissue. Moreover, there occur cases of more or less probable induction, as well as malformations which permit of various interpretation. Disturbances similar to induced ones, due to unknown factors, are very rare.

The following figures make it possible to judge of the relative frequency of induction under experimental conditions. As a result of replantation of the overturned optic cup in the axolotl in 90% of the cases is observed a doubling of the retina. In *Pelobates*, the eye turned (at various stages) together with the lens anlage and having more or less preserved the position it was given, has a second retina in 30% of the cases, whereas in the remaining ones towards the skin is turned the pigment epithelium, on which the chorioidea appears.

Thus, the contact of the eye rudiment with the overlying ectoderm is undoubtedly a retina-forming factor. The prospective lens, i. e. that area of the ectoderm which is normally adjacent to the optic cup, seems to induce most intensively.

The other side of interaction—induction of the lens by the retina—is known for a long time and has been experimentally investigated by a number of authors (2). It stands to reason that in our experiments it is operative only in those rare cases where the eye might have inlfluenced the ectoderm of a foreign region. The formation of the lens is a secondary effect of interaction and it demands a more prolonged contact than the retina formation does. All the cases encountered refer to *Pelobates*: in 3 of them the lens developed out of an ectoderm having substituted the lens-forming area, and in 2 other ones it was induced at another point, dorsally from the eye of the host. As compared with the cases known in literature, the peculiarity of these cases consists in that the inductor itself (second retina) was formed under the influence of the ectoderm, in which later it induces the formation of complementary structure.

The new complex system, evidently, arises as a result of the interaction of the embryo parts which in their previous development have been prepared for this only in general properties. Both constituents of the future eye exhibit morphogeneous potencies according to their appurtenance to a definite reactive system (covering ectoderm, optic vesicle), whereas their narrow specifity is established in the very process of interaction, and to none of them can be attributed a chief determining rôle.

The contact is, however, not the only cause of the formation of retina and lens. The material of the eye grafted much earlier, at the neurula stage, is able to self-differentiation; while the epidermic ectoderm after a previous removal of the eye anlage may give, at least in some species, a lens rudiment, though a weakened one (2). The author's experiments on various species of *Urodela* and *Anura* have shown that self-differentiation not necessarily involves a detailed determination of the rudiment; a bit of pigment epithelium, or of retinal layer from the optic cup, transplanted into a neutral environment, may develop into an entire optic cup with differentiated parts (3, 4). In *Triton taeniatus* the potencies of the parts of the primary optic vesicle are not divided, and there is no determined anlage of the retina.

Only gradual differences of the distal pole are observable, its specifity being gradually fixed at the period of contact with the ectoderm ([4]). Thus, evaluating the factors of the normal development of the optic cup, account should be taken both for the early anisotropy in its material and of the contact influence. The specific differences are a matter for future studies. It is very likely that the rate of detailed determination varies for different forms, and that, accordingly, the eye differentiation proceeds at times more, at others less autonomously. As to the lens formation, it is well known that in most of the amphibians that have been used for experiment, the rôle of induction is very great; without the optic cup the lens either does not form at all, or else it is represented by a reduced rudiment ([2],[5]). Nevertheless the lens area of the skin ectoderm is not altogether passive and in some species clearly displays a tendency to produce the lens ([2]).

Consequently, under natural conditions those places of the eye and epidermic ectoderm come into contact which possess the highest ability to morphogenetic reaction.

The interaction may be roughly characterized as an activation of the constituents; it makes the gradual differences in their material more conspicuous, causes or at least increases a definite morphogenetic effect. Owing to the localized effect of induction, in both cases, spatial relations and size proportions of the rudiments are correlatively established. Thus, interaction appears not only as a factor of differentiation of the embryo, but also as a factor of integration of a complete system—first of all, of an organ compound by its origin.

Obviously, the importance of reciprocal induction is the greater, the more labile are the preceding phases of development and the less co-ordinated are the determinative and form-building processes at early stages. Judging by the great individual variability of embryos, relative displacements of the presumptive rudiments are very probable, and, as in every variation row, slight deviations from the norm are the most frequent to occur. It may be easily seen that the correlation here analyzed (like others of the same character) may act as a normalizing factor. However, one should not ascribe to this circumstance any absolute importance; the results of experimental induction confirm the rule that a fully normal organ may be formed only in its normal place, i. e. in case a definite complex of conditions be available.

The very fact of morphogenetic interaction of systems, more or less capable of self-differentiation, makes one look into the historical development of correlation. Was the inductive connexion developed in the process of evolution parallel to the unification of structures of different origin into one organ, or else, did the system arise on the basis of interaction, progress consisting in an independent determination of the constituents? The solution of this question it rather difficult, in so far as the origin of the eye in vertebrates is practically unknown. Yet, comparative experimental study of recent forms of animals can largely contribute to the understanding of the evolution of organizing factors. With regard to the eye development dynamics, comparative method has been used for a long time; it is, however, of merely empirical origin. A number of investigations are concerned with the varying dependence of the lens formation ([2], [5]). Till now, attempts to connect its rate with the position of a given species in the system have failed; however, there are literary data in favour of evolution from entire dependence to self-differentiation (H. Spemann, B. Dürken, D. Filatov, A. Mashkovzeff). The question has not been emphasized as regards the optic cup, its ability to self-differentiation having been proved more than once.

Now we have reasons to consider this ability against the background of interaction, too, and to question the variability of its importance.

One can hardly speak of autonomization of embryonic rudiments in the course of evolution as of some general principle. Embryogenesis of vertebrates, inclusive of the most progressive classes (warm-blooded), refers to the «regulative» type. Morphogenetic correlations are here very widely spread—they play an important organizing rôle in the individual development and must tell on phylogenetic transformations. I. I. Schmalhausen, when analyzing the manysided problem of the development of the organism as a whole, considers as very probable a progressive differentiation of correlations alongside of simplification and a more strict specialization of connexions which determine the formation of each separate structure ([6]). This view can evidently be adopted as a working hypothesis for further research.

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ZOOLOGY

A PROCEDURE FOR INVESTIGATING AGE AND GROWTH IN *REPTILIA*

By V. L. BRYUZGIN

(Communicated by I. I. Schmalhausen, Member of the Academy, 16. III. 1939)

In spite of the great theoretical interest and, as it now appears, no small practical value of *Reptilia*, their biology is but little known, while the age and growth of some of the groups of *Reptilia* has been scarcely studied if at all (snakes). The latter circumstance has prompted us to work out a method for studying the age and growth of snakes.

For the investigation were used snakes, most frequently met in the south of Ukraine—*Natrix natrix*, *N. tesselata*, *Coluber jugularis*, *Vipera renardi*, *Coronella austriaca*, from 1936—37—38 collections*, fixed with formalin.

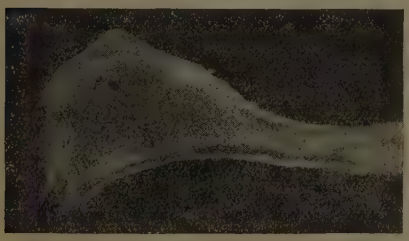

Fig. 1. Os transversum of a *N. natrix* (one year old).

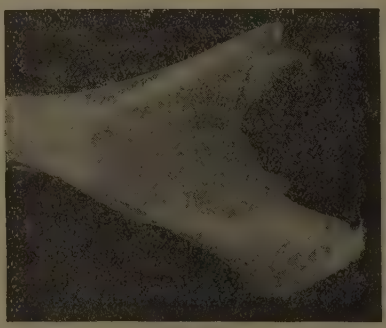

Fig. 2. Os transversum of a *Coluber jugularis* ($11^1/_2$ years old).

Considering that in *Reptilia* which are poikilothermic animals, nutrition and metabolism, and consequently growth, are intimately connected with the temperature of air, we have arrived at a conclusion that such a seasonal variation in growth is apt to leave traces on the bones in reptiles**, like in fishes. The latter are known to possess on the bones and scales alternating wide and narrow growth rings (bands) which correspond to definite

* The material has been collected by the zoologist I. I. Yaremenko of the Berdyansk Pedagogical Institute and the author.

** Scales of reptiles do not bear evidence of the periodicity of life, as they are replaced each year in the process of shedding.

seasons of the year passed by the fish, and judging by which the age of fishes is usually determined.

We have investigated head bones, mainly those outside the cranial box. The bones to be investigated were cleaned of the muscles and thoroughly scrubbed with a short-trimmed tooth-brush, whereupon they were dried in the air, and then, for clarifying, subjected to a six-hour glycerin treatment. After having been treated in the above manner, the bones were examined under a binocular microscope with a 15 and 20 magnification.

As a result of examination of most of the head bones of the above-mentioned snakes we detected on the os transversum, in the anterior region, as well as on os supra-angulare, regularly alternating narrow and wide bands. Comparison of body dimensions, size of the investigated bone and the number of bands on the bone made us conclude that in snakes, like in fishes, in

Fig. 3. Os transversum of a *N. natrix* (9 years old).

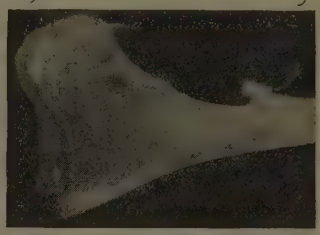

Fig. 4. Os transversum of a *N. tessellata* ($4^1/_2$ years old).

winter, during the period of cessation of nutrition, the bone grows scarcely if at all; in the spring and summer, during intensive feeding, the bone grows fast, and a broad band is produced, separated from the previous broad band by a narrow, more transparent one. Thus, the broad growth zone separated from the previous one by a narrow, more transparent band (for the same reason as in fishes, let us call it the winter ring) corresponds to the time lived through by the snake from the start of intensive feeding in the previous year up to the beginning of intensive feeding in the following year, i. e. the broad summer ring and the narrow one of winter are produced as a result of a phenological year passed by the snake; consequently, the age of snakes can be determined simply by counting the winter rings on the os transversum. Thus, photograph 17 shows the anterior region of os transversum of *Natrix natrix*, 250 mm in length, with but one winter ring. Hence, this grass-snake has passed through but one winter. Photograph 19* of the os transversum of *N. natrix*, 795 mm long, shows 10 winter rings pointing to that this grass-snake has lived through 10 winters. Considering that the first winter ring marks the section of the bone which had been formed during the period of embryonic development and the time from the beginning of the snake's growth, after it has hatched from the egg until the ensuance of the following phenological year (beginning of intensive feeding after the winter torpor, which is about 5—8 months), the date of the snake's capture having been taken into account, the age of No 17 is determi-

* The numbers of the photographs correspond to those indicated in the table.

ned as equal to 9 months, that of No 19, possessing nine winter rings, 9 years and 5—8 months.

To illustrate the foregoing comparative figures are tabulated below.

No from the record	Snakes	Absolute length in mm	Number of winter rings	Age in years
17	*Natrix natrix*	250	1	0.75
1	» »	471	5	5.5
11	» »	760	7	7.5
9	» »	775	9	9.5
19	» »	795	9	9.5
8	» »	1030	11	11.5
20	*Natrix tesselata*	510	4	4.5
18	*Coluber jugularis*	1090	12	12.5
12	*Vipera renardi*	510	6	6.5

In conclusion it should be stated that, making use of the above procedure of determination of the age of snakes, one can study their age and growth on large material assembled directly in natural surroundings. This would be of great value for taxonomic and biocoenotic investigations.

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PARASITOLOGY

A NEW PARASITE OF THE LUNGS IN RODENTS

By J. D. KIRSCHENBLATT

(Communicated by I. I. Schmalhausen, Member of the Academy, 9. III. 1939)

Two years ago I studied the dynamics of the parasite fauna in mouse-like rodents of Transcaucasia (1). I dissected various species of rodents. In the lungs of some of them I frequently happened to come across rather large white cysts surrounded by thick envelopes. The contents of the cysts consists of very fine granules. When the envelope is broken, the granules pour out. The number of cysts in the lungs usually reaches several dozens. Cysts of quite different dimensions are met together.

To study carefully the structure of these cysts, series of microscopical sections were made and coloured with Heidenhain's iron haematoxylin. The cysts proved to be a new peculiar parasite species, belonging to the genus *Rhinosporidium* Minchin and Fantham, 1905. This genus was till now supposed to consist of only two species—one being a parasite of man and the other of horse. The former, *Rhinosporidium seeberi* (Wernicke, 1903), causes ramified polypoid tumours of the nasal cavity and the nasopharynx of man. It can also be found, though rarely, on the conjunctive, in lacrymal sacs and on the surface of the penis. The latter species, *Rhinosporidium equi* Zschokke, 1913, lives in the nasal cavity of horse and mule and also causes polypoid tumours on the mucous membrane of the nasal septum. On the one hand, some scientists number *Rhinosporidium* among *Sporozoa* of the order *Haplosporidia*, referring it, together with several other genera, to suborder *Polysporulea*. On the other hand, some other authors, particularly Ashworth (2), after having carefully studied the development of the cysts and the spore formation in *Rhinosporidium*, have referred it to the lower fungi of the family *Chytridiaceae* (order *Phycomycetales*). The fact that the new species of *Rhinosporidium* has been discovered in the lungs, is of special interest, since the typical habitat of the other species of this genus is the nasal cavity and nasopharynx, i. e. the upper part of the respiratory system.

The new species is given by us the name of *Rhinosporidium pulmonale* sp. n.

The largest cysts discovered in the lungs of *Microtus socialis satunini* Ogn. are 255 to 282 μ in diam. They are covered with an envelope 27 to 31 μ thick, consisting of two layers of different composition. Similarly to the envelope of *Rhinosporidium seeberi*, it has a thin external layer less than 1 μ thick, consisting of chitinoid substance, and a thick internal layer, apparently of cellulose. The latter exhibits fine concentric laminate structure. The spores, situated in the central part of the cyst, are lighter and have a diameter of about 3 μ. Those lying nearer to the periphery are much darker and

have only about 1.5 μ in diameter. I failed to detect any opening (micropyle) in the envelope of the cysts.

Rhinosporidium pulmonale in *Microtus socialis satunini* Ogn., *Apodemus sylvaticus* L. and *Mus musculus abbotti* Waterh. were found by me in the vicinity of Tbilissi (Georgia), in *Chionomys nivalis* Mart. at Nalband (Armenia) and in *Spalax monticola* Nerh. at Amamly (Armenia). The most frequent occurrence of *Rhinosporidium* was observed in *Microtus socialis satunini* Ogn.

Fig. 1. Lobe of the lung of *Microtus socialis* affected by *Rhinosporidium pulmonale*. ×7½.

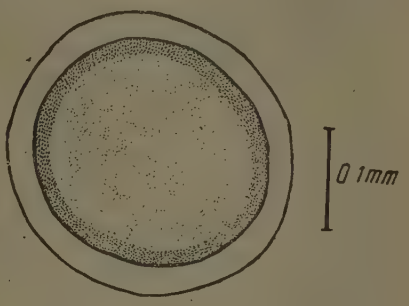

Fig. 2. Section through the cyst of *Rhinosporidium pulmonale*.

Table 1

Seasonal Distribution of *Rhinosporidium pulmonale* in Rodents in the Environs of Tbilissi

Months	IV 1936	V 1936	VI 1936	VII 1936	VIII 1936	IX 1936	X 1936	II 1937
Number of rodents	23	34	25	26	30	28	8	49
Number of infected rodents . .	3	2	1	0	1	1	0	9
Percentage of infected rodents .	13.04	5.88	4.0	0	3.33	3.57	0	18.74

Table 2

Age Distribution of *Rhinosporidium pulmonale* in *Microtus socialis satunini* Ogn. in the Environs of Tbilissi

Weight in g	6—14	15—19	20—24	25—29	30—34	35—39	40—44	45—49
Number of voles	13	10	17	18	17	17	9	3
Number of infected voles . . .	0	0	3	1	1	4	1	0
Percentage of infected voles . .	0	0	17.64	5.55	5.88	23.53	11.11	0

Dissections showed that the percentage of rodents infected with *Rhinosporidium* is subject to seasonal variations (Table 1). The highest percentage of rodents infected corresponds to winter and early spring. Summer heat and dryness of the soil seem to kill the spores of *Rhinosporidium pulmonale* and thus to hinder the infection of new rodents with the parasite. We could establish no dependence of the distribution of infection either upon age* or sex** of the rodents (Table 2). The youngest voles proved uninfected, while in *Mus musculus* infection was observed chiefly among the youngest individuals (weighing from 6 to 14 g).

In the lungs of healthy rodents I have never found any traces of their having gone through the *Rhinosporidium* infection. As the rate of infection does not increase with the age of the rodents, it is to be assumed that the rodents are susceptible to the *Rhinosporidium* infection at any age, and that heavy infection results in relatively early deaths of the rodents. It is the more probable on account of the fact that the cysts usually affect a very considerable part of the lungs, the latter circumstance being undoubtedly very unfavourable for respiration.

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* The weight of the mouse-like rodents was used as a relative index of their age differences ([3]).

** Till now *Rhinosporidium seeberi* (Wernicke, 1903) was met only in male.

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PALEOZOOLOGY

STRATIGRAPHICAL VALUE AND TYPES OF *CHAETETIDAE* OF THE CARBONIFEROUS OF THE USSR

By B. S. SOKOLOV

(Communicated by A. A. Borissiak, Member of the Academy, 22. III. 1939)

The rapidly growing interest to the *Chaetetidae* fauna of the USSR (particularly of the Russian platform), both on the part of Russian and foreign scientists (Peterhans, Heritsch, Condra and others), has induced me to publish the present paper without waiting for the appearance of the monograph dealing with this fauna.

Up to the present but two genera of the family *Chaetetidae* have been known in coal deposits of the USSR: *Chaetetes* Fischer 1830 and *Chaetetipora* Struve 1898; the latter was never mentioned in geological literature since the time of its establishment. The two genera have a wide range of distribution in the Russian Carboniferous, however, they are not the only representatives of the family under consideration. A detailed study of the structure of *Chaetetidae*, of their mode of reproduction, and especially cell morphology, permits of the differentiation of a few more peculiar groups of this family, part of which are positively to be regarded as independent taxonomic units.

According to the mode of reproduction, all *Chaetetidae* known from the Carboniferous are classed into two groups; the former of them is characterized by reproduction by fission (formation of pseudo-septa), while basal gemmation (absence of pseudo-septa) is typical of the latter. However, occasionally both modes of reproduction may concur; thus, for instance, characteristic of the former group at the initial stage of development is to reproduce by way of basal budding. The appearance of pseudo-septa in the latter group is rather exceptional. Polyparia of the former group are always spherical in form, with radially disposed corallites; those of the latter group are lamellose with a parallel arrangement of corallites. According to the mode of disposition of corallites, a third group may be discerned, in which the corallites are arranged about one or several axes, exhibiting in their longitudinal section a feathery structure (*Ch. scheremetewi* Boekh.= *Ch. fischeri* Stuck, *Ch. pinnatus* sp. n. and others).

According to the shape of cells, *Chaetetidae* fall into four groups: 1) cells honeycomb-like, polygonal, thin-walled; 2) cells irregular, with a thicked out, more or less undulate wall and a rounded visceral chamber (smoothed angles); 3) cells meandrous, thin or thicked out, often with uncompleted fission of the visceral chamber by pseudo-septa, and 4) cells polygonal, rounded with contiguous independent walls.

The first 3 groups are characterized both by the spherical and lamellate types of *Chaetetidae*, the second group being more sharply differentiated within the spherical type.

Thus, the extreme forms of cell variation are the honeycomb-like and meandrous forms which, with very few exceptions, never occur together.

Definite combinations of structural and morphological characters of polyparia, as indicated above, are rather persistent in some of the groups and serve as a basis for the taxonomy of *Chaetetidae*.

As to the microstructure of walls in *Chaetetidae* which has of late assumed particular importance in the classification of this family, it is here uniform throughout, and in general could hardly serve as a reliable basis for the taxonomy, as it is rarely well preserved and is easily changed under the action of secondary processes. The question of the external structure of walls in *Chaetetidae* I believe to be more important, i. e. whether they are continuous, common to adjacent cells, or each possesses a wall of its own. The microscopic study of *Chaetetidae* has so far not warranted an ultimate solution of this question, however, it should be noted that the presence in some instances of dark striae running across the middle of the walls is an undoubted evidence of their isolation. Besides, a whole group of forms may be segregated as unquestionably belonging to *Chaetetidae* because of their manifestly disconnected walls. And it would not be reasonable to think otherwise, since the wall had been deposited by each zooid independently, though in many instances the suture between the walls could become effaced until obliterated altogether, owing to purely biochemical causes and secondary processes.

The next, no less important question, is the one of relationship between the zooids, i. e. the communication of neighbouring cells with one another. Since this question is being discussed in more detail elsewhere, it should be herein mentioned that alongside of typical *Chaetetidae* with solid and aporous walls, there exists a certain group of genuine *Chaetetidae* possessing spongy walls with more or less distinctly outlined pores (*Spongiothecopora* gen. nov.).

Upon a study of coal *Chaetetidae* of the USSR (collection numbering about 1500 specimens), the diagnosis of this family may be briefly formulated as follows.

Colonial polyparia formed by polygonal or meandrous cells separated by tabulae developing in the shape of globular masses or plates and reproducing by fission and basal gemmation; there is no lateral budding in *Chaetetidae*. The cell diameter ranges from 0.2 to 1.2 mm, the thickness of walls from 0.02 to 0.3 mm. Walls of adjacent cells are continuous or disconnected, aporous and rarely spongy. The total absence of septa and of similar structures induces one to place this family in sharp contradistinction to typical *Tabulata* and regard *Chaetetidae* as a larger independent taxonomic group (*Chaetetida*), related to *Tabulata* merely by the possession of tabulae and in still lesser degree than *Heliolitida* and *Tetradida*. Being that tabulae are peculiar not to *Tabulata* alone, but to other groups of *Coelenterata* and even to other types as well, the very coralline nature of *Chaetetida* may be challenged.

Brief diagnoses of genera and groups included in *Chaetetida*:

A) 1. *Chaetetes* (Fischer) em. m. Polypary of spherical shape; composed of polygonal thin-walled cells; reproduction by fission. Genotype—*Ch. radians* (Fisch.). Moscovian subdivision. C_1—C_3 and P?

2. *Chaetetipora* (Struve) em. m. Polypary spherical in form, composed of meandrous cells, often with uncompleted fission of the visceral chamber; multiplies by fission. Genotype—*Ch. confluens* Struve. Visean. C_1.

3. *Moscovian*. Polypary of spherical shape, formed by disconnected

rounded polygonal cells; reproduces by fission. Genotype—*Moskovia distincta* Sok. (sp. n.). Moscovian stage. C_2.

4. Group *Ch. boswelli* Heritsch (*Boswellia* m.). Polypary of spherical shape, composed of thickened irregular cells, with undulate rounded visceral chamber; compact walls; reproduction by fission. This group occupies an intermediate position between *Chaetetes* and *Chaetetipora*. C_1—C_2.

B) 5. Group *Ch. filiformis* Sok. (sp. n.) (*Chaetetella* m.). Polypary of lamellate structure, composed of parallel, prismatic minute polygonal cells; multiplication by means of basal buds. C_1—C_2.

6. Group *Ch. crustaceus* Sok. (sp. n.) (*Chaetetiporella* m.). Polypary lamellose in shape, composed of cells of irregular and meandrous form; reproduction by basal gemmation. C_1.

C) 7. Group *Ch. pinnatus* Sok. (sp. n.). Multiform polyparia, ranging any way from mat-like to spherical; mostly composed of irregular and meandrous cells grouped around one or several axes of growth (feathery structure); reproducing mainly by fission.

The enumerated groups, with the exception of the last one, are genetically closely related to one another, as well as to the above described genera, and may be provisorily regarded as subgenera of *Chaetetes* and *Chaetetipora*.

Chaetetida have an extremely wide geographical range in the Carboniferous. At the present time representatives of *Chaetetida* are common in the Carboniferous of England, Central Europe, the entire European part of the USSR, Novaya Zemlya, Timan, Ural, Siberia, Middle Asia, Tyan-Shan, Mongolia, Northern and Southern China, Indo-China, Japan, North America, etc; the absence of *Chaetetida* in the Kuznetzk basin is rather conspicuous. It is noteworthy that the Lower Carboniferous fauna of the USSR is most closely related to the fauna of Western Europe, and the Middle Carboniferous—to that of China (Penchi series, Weiningian, Huanglung limestone), Japan, North America (Des Moines series). The most varied and abundant fauna *Chaetetida* ranks in the European part of the USSR (C_1—C_2); it had flourished in the Visean and Moscovian epoch.

A detailed stratigraphical analysis of the fauna *Chaetetida* together with paleoecological material is given in my monograph devoted to *Chaetetida* of the European part of the USSR, while herein I am bound to indicate but the largest complexes of forms which have stratigraphic value. Of the Oka series C_1^{ok} are characteristic: *Chaetetes janischevskii* sp. n., *Ch. septosus* (Flem.) var. *lepas* var. n., *Ch. capillaris* (Phill.), *Ch. boswelli* Her.; *Chaetetipora confluens* Str., *Ch. cirrata* sp. n.; numerous lamellose *Chaetetida*—*Ch. filiformis* sp. n., *Ch. crustaceus* sp. n., *Ch. repens* sp., n., *Ch. conicellatus* sp. n. and many others. Of particular interest is the group *Ch. crustaceus* which had spread throughout the entire European part of the USSR at the confines of the Oka and Serpukhov time, and recently was found by the author in Middle Asia.

Of the Serpukhov series C_1^{serp} are characteristic: *Chaetetes rossicus* sp. n., *Ch. septosus* (Flem.), *Ch. janischewskii* sp. n., *Ch. tenuiradiatus* sp. n., *Ch. tabulicarens* sp. n., *Ch.* ex gr. *lungtanensis* Lee et Chu; *Chaetetipora textilis* sp. n., *Ch. arbustiformis* sp. n.; of those with lamellate structure—*Ch. depressus* (Flem.), *Ch. tenuistriatus* sp. n. and others.

The Uglov horizon C_1^{ugl} is characterized by: *Chaetetes rossicus* sp. n., *Ch. lungtanensis* Lee et Chu, *Ch. gracilis* sp. n., various forms of the group *Ch. pinnatus*.

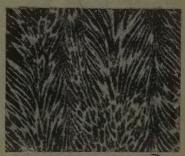
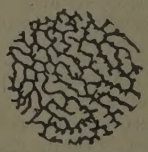
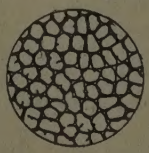
The moscovian subdivision C_2 is characterized by: *Chaetetes radians* (Fisch.), *Ch. fischeri* (Stuck), *Ch. lungtanensis* Lee et Chu, *Ch. flexuosus* sp. n. and other forms closely related to the Chinese fauna, as well as *Moskovia distincta* gen. sp. n. and many others; the fauna occurs in considerable profusion. In the Upper Carboniferous *Chaetetida* are sharply decreasing and thus far *Ch.* ex gr. *radians* (Fisch.) and *Ch. volgensis* Stuck may be mentioned. In the east the Upper Paleozoic fauna *Chaetetida* is more abundant.

There are altogether over 45 species of *Chaetetida* known at the present from the Carboniferous.

The above described fauna is widespread over the entire European part of the USSR, from Northern Dvina and Pechora to the Donetz basin; it is of remarkable stratigraphic persistance, and in many cases competes success-

fully with the *Brachiopoda* and *Rugosa* fauna. The Arctic fauna, that of Timan, and especially of Ural and Middle Asia is extremely close to the one indicated above, though unfortunately not yet fully investigated. However, it is now already possible to suggest the main index complexes for the Carboniferous of the Ural and Middle Asia, as being very close to those of Europe, though including some new species.

The study of *Chaetetida* group is a task rather worth-while, as it furnishes a great deal of new paleobiological material, and is conductive to a different estimation of the stratigraphical value of the coal *Tabulata*.

Mode of reproduction	By fission	By basal gemmation	Mainly by fission
Arrangement of cells	Radial	Parallel	Feathery
Form of colony / Cell form	Spherical	Lamellose	Multiform (mainly spherical)
Polygonal Thin-walled	*Chaetetes* (Fisch.) em. m.	Gr. *Ch. filiformis* Sok. (sp. n.) (*Chaetetella* m.)	Gr. *Chaetetes pinnatus* Sok. (sp. n.)
Irregular Thick-walled	Gr. *Ch. boswelli* Her. (*Boswellia* m.)	Gr. *Ch. crustaceus* Sok. (sp. n.) (*Chaetetiporella* m.)	
Meandrous	*Chaetetipora* (Struve) em. m. 		
Contiguous	*Moskovia* g. n. 		

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